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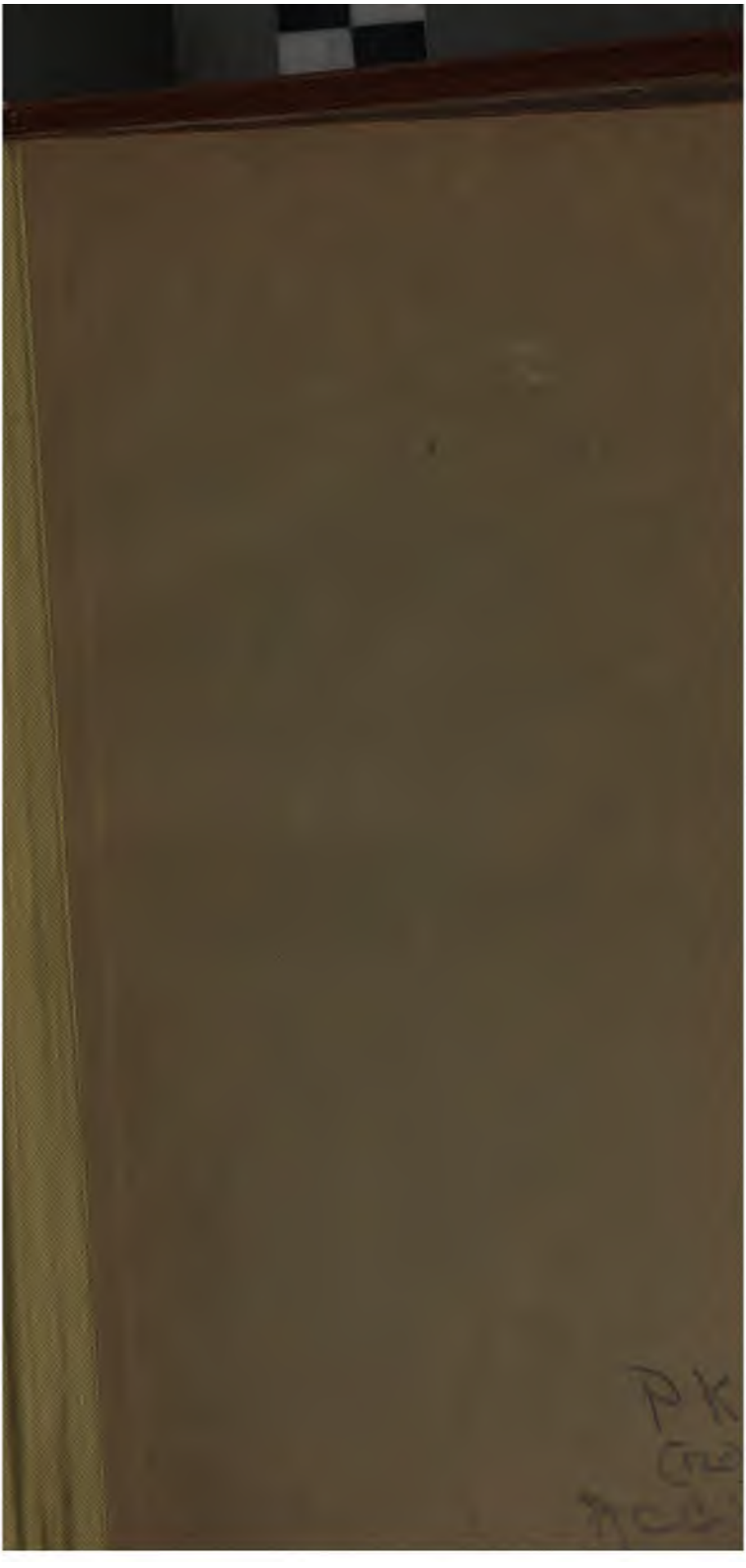
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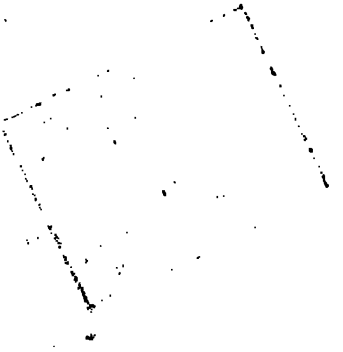
OF

THEORETICAL AND PRACTICAL

CHEMISTRY.







Accum's improved Gazometer.



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SYSTEM

OF

THEORETICAL AND PRACTICAL

CHEMISTRY.

IN TWO VOLUMES, WITH PLATES.

BY

FREDRICK ACCUM,

TEACHER OF PRACTICAL CHEMISTRY, PHARMACY, AND MINERALOGY;

AND

CHEMICAL OPERATOR

IN THE ROYAL INSTITUTION OF GREAT BRITAIN.

VOLUME I.

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THE MANAGERS

OF

THE ROYAL INSTITUTION OF GREAT BRITAIN,

FREDRICK ACCUM,

CHEMICAL OPERATOR TO THAT CORPORATION,

DEDICATES,

BY THEIR PERMISSION,

AND

WITH THE HIGHEST RESPECT AND GRATITUDE,

THIS ATTEMPT,

TO PROMOTE THE GENERAL PURPOSES

OF

THEIR ESTABLISHMENT,

BY EXTENDING THE DIFFUSION

OF

SCIENCE.

PREFACE.

11, *Old Compton Street, Soho.*

THE following treatise has been composed for the instruction of such as are actually unacquainted with chemical science; and with that view I have followed such an arrangement of the subjects, as appeared best calculated to afford a clear and permanent knowledge of their relations and consequences.

As the proofs of chemistry are grounded upon an appeal to the senses, I have in the first place described some experiments, which are easy to be performed, and particularly adapted to exhibit the general nature of chemical action.

But mere facts do not constitute a science. The reasoning faculty must be exerted to dispose them in the order of cause and effect; first by the method called analysis, and afterwards in that of synthesis: which last may be considered as including those tentative processes of the mind called hypotheses, which in natural science are rendered legitimate by experiment.

The metals, alcalies, earths, &c. next succeed, and are treated in the same manner by direct reference to the facts they afford during chemical examination. The natural history of each, and their obvious physical and chemical properties are first stated; then follow the means of obtaining them; and lastly, their physico-chemical properties are shown, by a series of experiments. A similar method pervades the whole of the work.

I have endeavoured experimentally to unfold all the fundamental truths of the science. I have proceeded from first notions step by step; from generals to particulars; from premises to conclusions; deducing causes from their effects, and effects from their causes, in order to maintain a systematic connection between the several parts of the whole, and to recall to the memory, all the changes which bodies are susceptible of in their mutual actions.

I am persuaded this cannot be better done, than by determining their properties by experiments under different circumstances. Hence the same facts are exibited under various forms and relations, in order to oblige the mind to re-consider the same phenomena in different lights.

It is perhaps needless to state, that I have availed myself of all the authors who have cultivated and enriched this science. In many instances I found perspicuity of style and precision of detail, which I could not hope to make improvements; and in such cases I have not scrupled to transcribe whatever answered my purpose. But I have faithfully quoted my authorities, and rendered honor to whom honor is due.

They who are familiar with the science will nevertheless observe that I have done more than borrow from others. I have corrected errors which are found even in the works of modern authors of eminence; particularly in respect to the practical part of many processes. I have facilitated many operations; I have advanced a variety of new experiments, and pointed out such particulars in the performance of others as I have found in the course of my profession to be superior to those in general use.

The directions for performing chemical experiments, and the explanations in general, may be considered by some readers as too minute: but I am fully convinced that chemistry cannot be learned without actually applying to the operative part of the science. It is obvious that success must greatly depend on minute and clear instructions: this method of teaching cannot therefore be deemed trifling. I have indeed written for beginners: but accuracy and precision are so far from being faults, that they are more acceptable even to proficients, than that loose descriptive method which leaves the whole detail of quantities, order, and operation, to be supplied by the trials of the reader himself.

LONDON,
1803.

FREDRICK ACCUM.







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Venables, Mr. Robert, No. 12, Holborn-court, Gray's Inn
Villiers, Mr. Arthur, Aberdeen
Vulliamy, Mr. Travers, Temple
Walker, —— Esq. Conduit-street, Hanover-square
Warren, Captain, Poland-street
Watts, Mr. Greek-street
Webster, Mr. Clipstone-street, Fitzroy-square
Weekes, Mr. H. at Mr. Whitfield's, St Thomas's Hospital
West, Admiral
West, Mr. Charles, Oxford
West, Mr. James, North Weston, Oxford
Wheldon, Mr. Wigmore-street
Whitbread, Lieut. Col. New-street, Berkeley-square
White, Mr. Anthony, at Mr. Carlisle's, Soho-square
White, Mr. George, Devonshire-place, New-road
White, Mr. William, Cambridge College
Wilkins, Mr. Arthur, Tunbridge Wells
Wilkins, Mr. James, High-street, Paddington
Wilkins, Mr. Stationer's-court, Ludgate--street
Wilkinson, Mr. George, Leather-lane, Holborn
Wilkinson, Charles, Esq. Soho-square
Wilkinson, James, Esq. Pall-mall
Williams, Miss Strand

Williams, P. H. Esq. Ibotson's Hotel, Vere-street
Williams, Mr. Bruton-street, Bond-street
Williams, Mr. Stamford-hill
Willington, Mr. Castle-street, Oxford-street
Willis, Mr. New-street, Covent Garden
Wilson, Mr. Arthur, West-street, East Smithfield
Wilson, Mr. jun. Rotherhithe
Winch, ——, Esq.
Winfield, Rev. Mr. Chester
Winter, Mr. Optician, No. 6, Brewer-street, Golden-square
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Woödforde, Mr.
Woodhouse, Dr. Philadelphia
Woolcombe, Rev. Mr. Oxon
Wright, Dr. 9, Sackville-street
Wright, Mr. Soho-square
Wülknitz, the Baron de, Berlin
Xavier, Mr. Thedues, Lisbon
York, Mr. James, Hampstead
Young, Mr. Caleb, Oxford
Young, George, jun. Esq. Grocer's-hall-court, Poultry
Young, Mr. No. 19, Clifford's-inn
Young, Mr. Lamb's Conduit-street
Young, James, Esq. Edinburgh
Young, William, Esq. Islington

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A

SYSTEM

OF

THEORETICAL AND PRACTICAL

CHEMISTRY.

PART I.

SECT. I.

DEFINITION OF CHEMISTRY.

CHEMISTRY is that department of physical science the object of which is to investigate and account for the changes produced in all bodies in nature, by the mutual action of their parts upon each other, by means of which their physical properties are altered, and their individuality destroyed.

1. METHOD OF PERFORMING CHEMICAL OPERATIONS.

The method which chemistry employs to favor the action of bodies upon each other consists in the proper application of those substances to each other, which experience has taught us

are best calculated to produce certain changes, that, in many cases, would otherwise be too minute to affect the senses individually.

Those operations themselves are called CHEMICAL PROCESSES, or EXPERIMENTS.

2. GENERAL NATURE OF CHEMISTRY.

Chemistry therefore consists in a detail of those facts which are founded on *experiments* and *observations*. Its basis is EXPERIENCE; from this, by regular conclusions, it deduces a THEORY, and connects a series of accurately established facts into a certain order, called a SYSTEM.

It follows from this that the evidence of chemical truth is, strictly speaking, only probable, but not absolutely certain. This probability however is so much the greater, as the experiments on which the observations are founded are more numerous, and have been more accurately performed. All possible exceptions then being made, we may venture to consider the results which offer themselves as true, till other facts are furnished, which in a more satisfactory manner prove their fallacy.

It has been thus, by simple experiments and observation, that the science has been enriched with a store of facts. These facts have been gradually connected together, and arranged in such order as appeared most proper for exhibiting their reciprocal relation to each other; and, (at the same time) for referring them to a smaller number of general heads, in order to consult them with the least difficulty, and to trace the *laws* that regulate them.

SECT. II.

SUBJECTS AND IMPORTANCE OF CHEMISTRY.

ALL material bodies are the subjects of chemical research. The solid matters composing the terrestrial mass of the globe we inhabit; the aqueous fluids which penetrate its cavities, or float about its surface; the more subtle gazeous matter circumfused around it; the agencies of heat, light, and other imponderable substances expanded through space, are subjects for the chemical philosopher.

The events which chemistry holds out are equal to, and perhaps more important than those which belong to mechanical philosophy. It extends itself into the province of active life. It is the nursing mother and guide of innumerable important arts. The arts of dying, bleaching, tanning, glass-making, printing, the working of metals, &c. are purely chemical. *Agriculture* can only be rationally improved by calling in the assistance of the chemical philosopher; for it is chemistry which explains the phenomena of vegetation, germination, the growth, the ripening, and the death of plants.

The GARDENER, whose employments are more curious than those of the farmer, equally needs its assistance. The nature of the different manures necessary for the various kinds of vegetables, the influence of light, the different temperatures, the quantity of moisture, the preservation of seeds, roots, plants, &c. are all founded upon chemical principles.

Chemistry likewise directs the labours of the HUSBANDMAN and the RURAL-ECONOMIST. In the DAIRY milk cannot be kept

sweet and fresh, butter cannot be made, cheese cannot be prepared, without a skill founded wholly upon chemical principles.

The CULINARY ART, for preparing wholesome and nutritious food; and the method of preserving bacon, hams, and other animal and vegetable substances, is entirely chemical.

The whole PROCESS OF THE VINTAGE, the art of the brewer and distiller, the preparation of cyder, perry, and home-made wines, all depend upon chemical principles.

In MEDICINE and PHARMACY great benefits have been derived from the discoveries of chemical philosophers.

The chemist begins his enquiries where those of the natural historian and those of the natural philosopher terminate. The first of these examines bodies, in order to arrange them into certain classes, genera, and species: the second investigates the general properties of objects, such as their density, elasticity, figure, &c. and calculates the relative forces of their mechanical actions.

The chemist however goes further;...he looks into the more intimate structure of substances; he separates their heterogeneous particles from each other; he resolves them further into their simple or elementary substances, and examines their nature and properties when in a detached or simple state. He thus learns their reciprocal relation to each other, and becomes enabled to re-combine them in proportions different from those in which they were united by nature, in order to form new and useful compounds, which nature herself does not produce.

But chemistry is not only valuable as an art which supplies many of our wants, our comforts, and luxuries; its objects are sublime and beautiful in another point of view...it removes the veil from the fabric of nature, and makes us acquainted with all the phenomena which happen around us...it affords pleasure to the senses, and calls into action a laudable curiosity, which characterizes the minds of those who are of a scientific turn, exciting at the same time a spirit of rational enquiry, which is capable of producing the most beautiful and striking phenomena, well calculated to serve as an instructive and rational amusement.

SECT. III.

VIEW
OF
THE HISTORY OF CHEMISTRY.

FROM what has been already stated, it becomes obvious that chemistry may be considered both as a science and as an art:... As a science, it may be said to be of modern date; but as an art, it must be coeval with the earliest exercise of the industry of man; for many operations now considered chemical, certainly must owe their invention to the immediate wants of society. The method of kindling fires, the arts of baking bread, moulding clays, and burning them into pottery; extracting metals from their ores, the methods of working them, and various other processes, were certainly known to the ANTEDILUVIANS. If we attempt to trace its birth, as a science, we find it originating in fables and obscurity; nor indeed could we derive any chemical advantage, if it were possible to dispel the cloud by which it is enveloped.

Whether Tubal-Cain who is stated to have been a worker in metals, whether Noah who made wine, and who preserved the requisite stores of provisions in the ark, during the deluge, whether Moses who burnt the golden calf of the Israelites, or whether Cleopatra who is said to have dissolved a pearl, understood chemistry, are questions important perhaps to the antiquarian, but of little value to the chemist. It is more plausible to suppose that a science so much depending on the state of the arts, the civilization of man, and the experience of ages, could not possibly exist in such a remote time. But, as it would be in some respect unpardonable for those who devote themselves to

the study of chemistry, to be utterly unacquainted with its history, we shall shortly notice the outlines of this history and fix the dates of the progressive discoveries of our predecessors which led to the establishment of the science.

The PHŒNICIANS were the first who applied themselves to the examination of the effect of different bodies upon each other, which may be called chemical. They invented the art of tinging garments with a purple-coloured matter, produced by a species of shell-fish. They were likewise the inventors of making glass, artificial gems, perfumes, and odoriferous balsams. They also invented the art of preserving the fruits of various plants and vegetables.

The CARTHAGINIANS, who were a colony of the Phœnicians, learnt their arts; but the priests in whose hands the learning was retained, handed them to their successors veiled in hieroglyphic mystery.

The GRECIANS derived their arts depending upon chemical principles from the Phœnicians. They practised all the inventions of their predecessors successfully.

It is natural that the obvious difference or changes of the bodies that surround us could not escape the notice of a people of so philosophical a turn of mind as the Grecians; hence both Aristotle and Empedocles taught the doctrine of the four supposed elements, air, earth, fire, and water.

The ROMANS, who were not distinguished among the nations of the ancient world as discoverers in the arts, or inventors in science, after having conquered and subjugated almost all the civilized parts of the earth, arduously cultivated the arts of their masters, the Grecians. They understood the art of making excellent wines and ardent spirit. They knew the application of manures. They prepared incombustible cloth for wrapping up the dead bodies which were destined to be burnt, in order to preserve their ashes distinct from those of the funeral pile. They moulded clays, and converted them, by burning, into different kinds of pottery; they were also acquainted with almost all

the metals, and the methods of coining them. They were skilled in the culinary art. Their cooks invented delicious sauces, as luxuries for their table. And the remains of their aqueducts, and other works of architecture, evince the incomparable perfection of their cements.

But all the arts, the sciences, and literature of the Romans and Greeks were destined to sink into oblivion. Hosts of barbarian conquerors descended upon them from the North, the energies of civilization withered at their touch, and its works were destroyed before them.

Driven from Europe, the arts obtained an asylum with the ARABIANS, who improved many, and applied them to medicine. The attachment of this nation to magic, and their inclination for the marvellous, soon increased the mysteries in which the arts were then already involved; and hence alchemy, or the art of transmuting base metals into gold, took its rise. This happened about the commencement of the fourth century.

As this delusive dream of the imagination held out a bait to avarice, it soon acquired a train of followers. Intoxicated with the idea of the boundless wealth that would reward success, the great object was the philosopher's stone, and the possibility of the discovery of an universal medicine, which should cure every disease, and give immortal health and life to embodied man. The research was pursued with an ardour which no disappointment could damp, and the *mania* spread from one country to another. In Egypt it attracted the attention of the government. Diocletian, apprehensive that the dreams of the alchemists might be realized, ordered all their books to be burnt, in order that he might subdue them with more facility.

After this period the alchemists were strongly opposed by several able and learned men. They were considered as people who held intercourse with malevolent spirits. Roger Bacon, the alchemist, who is supposed to be the inventor of gun-powder, was excommunicated by the Pope and imprisoned ten years, for supposed dealings with the Devil; and Paracelsus was thought to

have an evil spirit confined in the pommel of his sword. Indeed, many of the adherents of alchemy endeavoured to enforce the belief of charms and spells; Paracelsus, the most impetuous man, who, in ostentation and lies surpassed all his predecessor alchemists, promised immortality in this world to his followers, but his premature death, which happened in 1541, exposed his vanity, and blasted all their hopes.

It would surpass our limits, were we to give a circumstantial detail of the state of the chemical arts at that period. It will be readily conjectured, that owing to the great numbers of experiments which were performed amongst the alchemists, many valuable discoveries must have been made unintentionally. The alchemists actually collected a rich store of important chemical facts, and if they did not succeed in drawing gold from their furnaces, they produced those materials on which the true science of chemistry was afterwards erected: *for as yet the science of chemistry did not exist.*

At the end of the seventeenth century chemistry began to assume a scientific form. The scattered chemical facts which the alchemist had discovered were collected, arranged, and reduced to principles.

The first chemical writer that excites our notice is Becher. This man collected all the facts which were noticed before him, and pointed out many important objects to which the researches of chemists ought to be directed. The publication of his *Physica Subterranea*, in 1669, forms a very important æra in the history of chemistry. At that period chemistry escaped for ever from the trammels of alchemy, and became the rudiments of the science which we find at present. Becher distinguished himself so highly by his chemical knowledge as to cause the names of all former theorists to be forgotten, after having laid the foundation to the famous system of phlogiston. He died in the year 1682.

Soon after his death arose one of his pupils, whose name was Stahl. He simplified and improved the doctrine of his master so much that he made it entirely his own; and accordingly it

has been known ever since by the name of the *Stahlean Theory*. He was the first who had a clear notion of chemical union, and gives many instances of double elective attractions. His writings have done him immortal honour, and ranked him amongst the first characters of the age in which he lived. He died in the year 1704.

Ever since the death of these chemists, chemistry has been cultivated with success. Men of eminence have appeared every where, discoveries have been multiplied which led to numerous important facts. The names of Margraaf, Scheele, Bergman, Baume, Rouelle, &c. will remain distinguished in the annals of chemical science.

The spirit of chemical enquiry which these philosophers had infused summoned on a sudden into action the faculties of the most learned men of Europe. Several of the invisible agents which form so important a part in the œconomy of nature were discovered. Dr. Priestley discovered in 1777, various aerial fluids, formerly totally unknown to chemists; Dr. Black traced the laws of latent heat, and discovered the carbonic acid. The science of electricity was (as it were) created, the thunder was taken from the clouds, and the properties of the atmosphere were examined with accuracy.

All these new discoveries embarrassed the votaries of the doctrine of Stahl; and the conclusions to which they led, were of such a nature as to puzzle and to contradict many of the laws of the science. It was requisite to take but one step further that the doctrine of phlogiston might be exploded for ever. This was left to Lavoisier.

Lavoisier, endowed by nature with the most happy genius for science, and favoured by his own princely fortune, and the liberal bounty of the French government, instituted a series of ingenious and accurate experiments, the result of which proved to demonstration that the theory of phlogiston was founded in error. His experiments were repeated under every diversity of circumstances by all the philosophers of Europe: his reasonings

and inferences were vigorously attacked by the defenders of th phlogistic theory; a kind of chemical war was thus kindled i the republic of letters, which was carried on with great anim sity; and posterity will see with regret, men of undoubted ge nius at times divesting themselves of the armour of truth an candour, and endeavouring to serve their party, and stab thei adverse fellow-labourers with darts steeped in the poison o calumny and falsehood. These things have passed away; th contest has been productive of good effects which infinitely ex pass the bad ones; it has occasioned an accumulation of facts produced a rigid examination of theories and opinions; introdu ced accuracy in chemical experiments, and given that ton and vigour to the cultivators of chemistry which have brought t light the most sublime and unlooked-for truths.

The principles of Lavoisier have triumphed, and are no taught in all the schools of Europe; his opponents have b come his disciples; and thus he has erected the luminous an beautiful theory of chemistry which all the chemists of Europ Priestley excepted, have now adopted. What a pity that the sa guinary tyranny of Robespierre should not even have spared th man, who perished on the 7th of May, 1794, under the axe the guillotine.

Amongst the number of philosophers, who have since that tim cultivated and enriched the new theory of chemistry, with disc veries which will for ever give immortality to their names, w have to notice Aikin, Babington, Bancroft, Beddoes, Blagde Cavendish, Chenevix, Crichton, Cruickshank, Davy, Lord Du donald, Lord Dundas, Fordyce, Garnett, Hatchett, Henry, Hi gins, Hope, Howard, Kirwan, Bishop of Landaff, Murray, N cholson, Pearson, Tenant, Tilloch, Thomson, Wedgwood, an Wollaston; Achard, Crell, Gilbert, Gren, Goetling, Humbol Hermbstaedt, Klaproth, Lowitz, Richter, Scherer, Tromsdor Westrumb, Wiegleb, Bertholet, Chaptal, Fourcroy, Lagrang Guiton, Van Mons, Proust, Sequin, Vauquelin, &c. &c.

ON THE

CORPUSCULAR THEORY;

AND ON THE

NATURE OF SIMPLE BODIES.

PART II.

SECT. I.

CORPUSCULAR THEORY.

WHEN we contemplate the objects around us, and confine our views to the globe we inhabit, we discover a vast variety of substances which may well excite our curiosity and arrest our attention. We perceive our earth to be a solid globe, composed of an assemblage of substances considerably fixed, and not to be destroyed without a considerable force of impulse. We observe a large part of it covered with an ocean, and numberless streams of cold liquid matter tending with great activity to incessant motion.

Around this earth and water, to a great but unknown height, is circumfused an atmosphere of an impalpable gazeous fluid, intermingled with portions of every solid or aqueous matter that by an extreme comminution is capable of suspension in this aerial fluid.

Different opinions have been formed concerning the question, in what manner this globe was brought into the present distribution of its parts.

Divines have endeavoured to justify the account of Moses, by an appeal to the present laws of nature. But Burnet and others have been easily convicted of supposing primæval states of things utterly incompatible with these laws.

Chemists have conceived that the origin of the earth, in its present form, is from a general liquidity of its whole matter: others again have attributed it to the action of fire.

Astronomers have been persuaded that it was owing to the action of some comet, or to an altered arrangement of the planets.

But none of these hypotheses are sufficiently consistent with the known laws of nature. We have no *data* to reason from except the agencies of the present physical laws; if we venture hypotheses incompatible with them, or if we attempt to conjecture what was prior to them, we of course reason unphilosophically. We shall therefore dismiss this question, and consider the matters which constitute this earth as they actually appear before us.

When we examine these substances with a mere superficial eye, we are led to conclude that they are composed of minute parts. If we examine the particles of many of those bodies which appear homogeneous, we discover that they consist of various distinct substances, whose properties are often widely different from those of the whole, of which they form a part.

Philosophers have from this inferred, that all bodies in nature consist of certain moleculæ or particles which never touch each other in any state hitherto known. When these particles are dissimilar, the body which they form is called a *compound*, or heterogeneous body; but when the particles are similar, they then form what is denominated a *simple*, or homogeneous body.

If, for instance, we take glass, which is a compound body, consisting of silex and potash, and reduce it to powder, each particle of glass, however fine, consists of a particle of silex and a particle of potash, bodies which are dissimilar to each other. But if we take a piece of sulphur, or a metal, and reduce it to powder, the particles which offer themselves are all alike; for the sulphur, or the metal, is a simple body.

SECT. II.

NATURE OF SIMPLE BODIES.

SIMPLE bodies consist of particles which cannot be further separated into others of a more simple nature, or reproduced by artificial means. The true character of them is immutability of properties, unity, and similarity.

It does not follow from this that these bodies are absolutely simple; on the contrary, it is very possible that they are compound. It cannot be doubted that, as the science advances towards perfection, many of them will be found so. Very probably a new set of simple bodies will offer itself, of which we are at present ignorant. These again may perhaps be decomposed, till at last, when the science has reached the highest degree of perfection, those really elementary substances will come into view, of which all bodies are ultimately composed. Whenever this shall happen the list of simple substances will probably be reduced to a much smaller number than at present; till this however does take place we are entitled to consider them as simple substances, according to the present state of our knowledge.

Their number amounts now to forty-five.

They may be conveniently arranged in the following order

SECT. III.

ENUMERATION AND CLASSIFICATION.

OF

SIMPLE SUBSTANCES.

DIVISION I.

SIMPLE SUBSTANCES PRODUCIBLE BY ART.

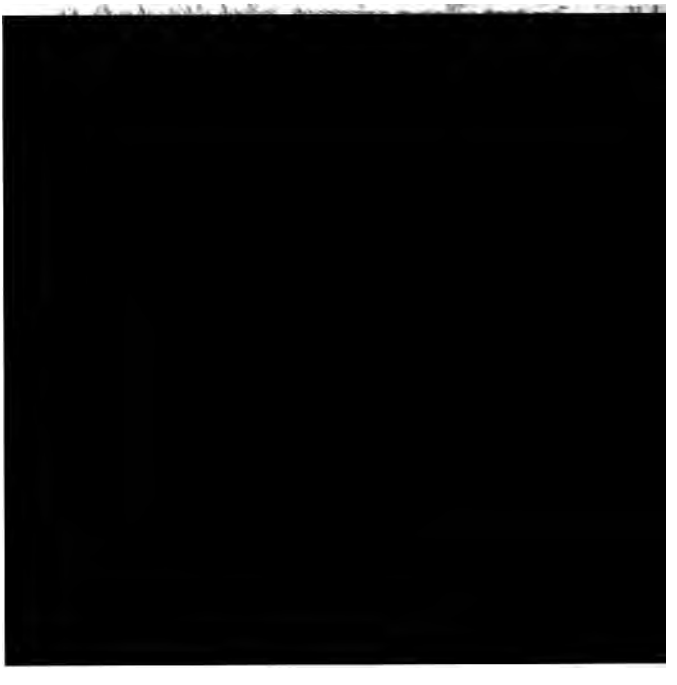
I. IMPONDERABLE SUBSTANCES.

Light
Caloric

II. PONDERABLE SUBSTANCES.

1. Combustibles, possessed of metallic properties.

Sulphur
Phosphorus
Carbon



INCOMBUSTIBLE BODIES.

7 EARTHS.

Silex
Alumine
Glucine
Zircon
Agustine
Yttria
Magnesia.

5 ALCALIS.

Barytes
Potash
Soda
Strontia
Lime

DIVISION II.

SUBSTANCES NOT YET PRODUCIBLE BY ART,
BUT
ANALOGICALLY CONSIDERED AS SIMPLE.

Oxigen
Nitrogen
Hidrogen
Muriatic radical
Fluoric radical
Boracic radical.

ch are the bodies which the corpuscular theory considers as le, and to which chemical writers have given the appellation ADICALS. Some can only be exhibited to our view in their le state, others on the contrary have not yet been suc- ully exhibited experimentally, uninsulated. Their exis- can nevertheless be inferred from the analogy of certain ral and well established facts.

ON

THE NATURE

OF

CHEMICAL ACTION.

PART III.

THE different actions which result from the proper application of the bodies enumerated before, when either in a simple state, or when combined together, are founded on certain agencies inherent in all matter. This we take for granted and consider as a fact, without pretending to explain *how* bodies came to be possessed of these agencies, or how they are capable of exerting it.

Philosophers therefore express the unknown causes which produce the changes by the metaphors of ATTRACTION and REPULSION.

Before we attempt to give an explanation of these terms, we shall endeavour to exemplify what is understood by chemical action in general. We therefore flatter ourselves that the following simple facts intended for that purpose, will not be deemed frivolous, our chief object being to advance in this place some palpable, positive, and negative proofs which show, that whenever chemical action takes place, the properties of bodies become altered, and their individuality destroyed.

SECT. I.

INSTANCES OF CHEMICAL ACTION.

EXPERIMENT I.

LET a small portion of marble, or chalk, reduced to powder, be diffused in a quantity of water, the marble presented to the water will fall to the bottom of the vessel and remain unaltered. On shaking up the whole, a white turbid mixture will be formed, but on letting it stand undisturbed, the marble will again fall to the bottom and the supernatant fluid remain transparent, and unaltered.

In this case no chemical action has taken place, for neither the properties of the marble or the water are altered if examined chemically.

EXPERIMENT II.

If we let fall a like quantity of marble or chalk into another fluid, called an acid; for instance, into vinegar, or nitric, muriatic, or sulphuric acid, the effect then will be different. A violent action will take place the instant they come into contact, the marble will gradually disappear in these fluids, and become more or less dissolved, and a transparent solution will be obtained.

In this case a chemical action has taken place between the bodies brought into the sphere of action, for the properties of both the substances can no longer be distinguished, their appearances are more or less altered, and their individuality destroyed.

Experiment III.

It is a well known fact, that if oil and water are added to each other they will not mix, because no sensible chemical action takes place between them under such circumstances; but if we add to the oil and water a sufficient quantity of another substance called an alcali, for instance, potash or soda, the oil, the water and the alcali will then unite and form a saponaceous compound which has a milky appearance, and renders water opaque.

A chemical action has then taken place between them, for the properties of the oil, the water, and the potash are lost; and a compound possessing new properties has been formed.

Experiment IV.

If we put into a phial equal quantities of oil of turpentine, highly rectified alcohol, and a concentrated solution of carbonate of potash, and shake them together, no chemical change takes place, the different fluids will apparently mix, but on suffering them to stand undisturbed, they will separate again and arrange themselves into distinct spherules. The heaviest fluid will sink with the greatest celerity, and they will place themselves over each other according to their specific gravities. *The different fluids will thus be contained in one phial, which do not mix but constantly remain separate.* In this instance therefore no chemical action takes place between the bodies presented to each other.

But if we bring the

Experiment V.

Accension of oil of turpentine, by the affusion of nitrous acid.

If we put into a tea-cup about one table-spoonful of oil of turpentine, and add to it double that quantity of very concentrated nitrous acid, a violent action takes place, and fire and flame will be produced.

Remark....As it is our duty to point out such experiments as may prove unsafe to those who never applied their hands to the practical part of chemistry, we must remark that in performing this experiment care should be taken to avoid dangerous events; for the cup is sometimes shattered to pieces, and the mixture is thrown about in all directions to a considerable distance; it is therefore necessary to fasten the vessel containing the nitrous acid to the end of a long stick, in order that the operator may be at a distance when the accension takes place, which happens the instant the acid comes into contact with the oil.

Experiment VI.

Production of heat, (sufficient to make water boil,) by the mere mixture of sulphuric acid and alcohol, or water.

If half an ale-glass full of sulphuric acid of commerce be hastily mingled with half that quantity of alcohol or water, the mixture instantly becomes so hot as to render the glass insupportable to the hands. A small quantity of water contained in a thin glass tube may be made to boil when immersed in it for a few minutes only.

Remark....Great caution is likewise necessary in making this experiment, lest the glass should crack from the sudden heat, and throw the mixture about to the manifest danger of the ope-

rator. The safest method is to mix the two fluids gradually; by this means the heat is produced slowly; whereas if both fluids are at once mingled together the heat is almost instantaneous, and rises considerably above that of boiling water.

Experiment VII.

Production of Sulphate of Potash.

If a concentrated solution, carbonate of potash, be mingled with sulphuric acid, the two fluids unite, a very brisk effervescence takes place, and a solid mass of salt (sulphate of potash) will be produced.

These experiments, which shall be more fully considered hereafter, are merely advanced to prove that the individuality of different substances becomes destroyed, that is to say, that a chemical action takes place when they are presented to each other, under such circumstances as experience has taught us are necessary to produce such effects. The conditions, or artificial arrangements requisite for that purpose, resolve themselves into the general operations of chemistry; these shall be circumstantially exhibited hereafter.

THEORY

OF

ATTRACTION.

PART IV.

THE terms attraction and repulsion, in the language of modern philosophers, are employed merely as the expression of the general facts, that the masses or particles of matter have a tendency to approach to, or to recede from one another, and to unite to, or repel each other, under certain circumstances. Hence the following

AXIOM OF ATTRACTION.

All bodies whatever have a tendency or power to attract each other more or less; they search as it were, and make efforts, when left to themselves, to approach one another in order to unite, or to come into apparent contact. This energy is called the POWER OF ATTRACTION.

This attraction is mutual; it extends to indefinite distances. All bodies whatever, as well as their component elementary particles are endued with it. It is not annihilated at how great a distance soever we suppose them to be placed from each other; neither does it disappear though they be arranged ever so near each other.

The nature of this reciprocal attraction, or at least the cause which produces it, is altogether unknown to us. Whether it be inherent in all matter, or whether it be the consequence of some other agent, are questions beyond the reach of human understanding; but its existence is nevertheless certain.

SECT. I.

PROOFS
OF
THE ENERGY OF ATTRACTION.

THAT the power of attraction really exists is obvious from t slightest view of the phenomena of nature. It is proved wi mathematical certainty that the celestial bodies, which constit the solar syst m, are urged towards each other by a force whi preserves them in their orbits. It is further proved beyond a doubt that this planetary attraction is possessd not only by t heavenly bodies as wholes, but that it also extends to the small particles of which they are formed, as may be evinced by mea of the following experiments:

EXPERIMENT I.



In both these experiments we see that there exists an attraction between the particles of mercury; in the first, the globules which are in contact with the plate of glass leave this substance completely, they attract each other and form a sphere greater in bulk. A mere inert fluid would in any case retain the figure it once possessed. It could not be endued with a globular form unless a real reciprocal attraction among its particles took place, which in the latter experiment is still more striking, for it there is not only superior to gravitation, but actually overcomes an external force.

Experiment III.

If a glass tube of a fine bore be immersed in water, contained in any vessel, the fluid will ascend to a certain height within the tube above its level, and its elevation in several tubes of different sizes will be reciprocally as the diameter of their bores.

This kind of attraction which takes place as well *in vacuo* as in the open air, has been called capillary attraction. It is this attraction which causes water to rise in sponge, cloth, sugar, sand, &c. for all these substances may be considered as fine tubes in which the fluid ascends.

Remark....The ascension of fluids in glass tubes of a fine bore succeeds best when the inside of the tube has been previously moistened, which may conveniently be done by blowing through it with the mouth. And if the water be coloured with a little red or black ink its ascension will be more obvious, particularly if the tube be held against a sheet of white paper.

Experiment IV.

If two plates of glass, previously wetted be made to meet on one side, and be kept open at the other, at a small distance, by the interposition of a shilling, or any other thin substance, and then immersed in water, the fluid will ascend between the two

plates unequally. Its upper surface will form a curve, in which the heights of the several points above the surface of the fluid will be to one another reciprocally, as their perpendicular distance from the line in which the plates meet. The ratio of this attraction is therefore as the squares of the increments with which the plates open.

Here then we have two other instances that an attraction prevails among the particles of bodies. For in both cases part of the fluid has left the contiguous mass, contrary to the laws of gravitation. It is drawn up as it were, or attracted by the tube, or plate of glass.

Experiment V.

If we immerse a piece of tin, lead, bismuth, silver, or gold, in mercury, and draw it out again immediately, the mercury will attract the metal, and the latter will carry with it a portion of the former, which will stick to it so obstinately as to be inseparable by mere friction.

There exists therefore an attraction between the different metals brought in contact with each other.

Experiment VI.

If a small stick be dipt in water, or any other fluid, and drawn out again, a drop will be found hanging at the end of it of a spherical form. The drop is spherical, because each particle of the fluid exerts an equal force in every direction, drawing other particles towards it on every side as far as its power extends.

Thus the very formation of drops obviously demonstrates that there must exist a cause which produces that effect. This cannot be gravity, for agreeable to experience that is rather an obstacle to the formation of drops; since by the weight of the particles, large globules resting on solid bodies are flattened, and their regular spherical form prevented.

To explain this phænomenon there remains only the power of attraction, acting between the particles of the liquid body, for if it is supposed that the particles of a substance reciprocally attract each other with equal force, and their aptitude for being moved upon one another be great enough to overcome any impediment to their motion, it follows by the principles of mechanics, that the equilibrium of the attractive forces can only take place when the mass has received a globular form.

Hence it is that all liquid bodies assume a spherical figure when suffered to fall through the air, or form drops.

Whether the attractions of gravitation and of cohesion, be, or be not considered as essentially the same, is not our business to consider here; there is difference enough between them to allow a very accurate examination of each.

SECT. II.

DIVISION OF ATTRACTION.

THOUGH we are unable to discover the cause of the mutual attraction, experience has proved to us that this agency follows certain conditions or laws; for similar phenomena always present themselves, whenever the circumstances of experiment are the same.

Observation has taught us that attraction takes place between bodies of the same kind, and bodies of a different kind. The first agency is called by physical writers *corpuscular attraction*, or *attraction of aggregation*; *molecular attraction*; *attraction of cohesion*, or *the cohesive power*.

The latter is termed *chemical attraction, chemical affinity*, or *affinity of composition*. But before we consider this subject any further we shall give an idea of what has been called *repulsion*.

THEORY

OF

REPULSION.

PART V.

It was mentioned before (page 21) that all matter possesses besides attraction, another power which is in constant opposition to the former. This agency which is equally powerful and equally obvious acts an important part in the phenomena of nature, and is called *the power of repulsion.*

AXIOM
OF
REPULSION.

All bodies are endued with a certain power whose constant tendency is to oppose their approach towards each other, or to remove the particles of matter to a greater distance.

SECT. I.

PROOFS
OF
THE ENERGY OF REPULSION.

THAT there exists a force which opposes the approach of bodies towards each other is evident from numberless facts.

Newton has shown that when a convex lens is put upon a flat glass it remains at a distance of the $\frac{1}{177}$ part of an inch, and a very considerable pressure is required to diminish this distance; nor does any force which can be applied bring them into actual mathematical contact; a force may indeed be applied sufficient to break the glasses into pieces, but it may be demonstrated that it does not diminish their distance much beyond the $\frac{1}{70000}$ part of an inch. There is therefore a repulsive force which prevents the two glasses from touching each other.

Boscowich has shown that when an ivory billiard-ball sets another in motion by striking against it, an equal quantity of its own motion is lost, and the ball at rest begins to move while the other is still at a distance.

There exists therefore a repulsion between bodies; this repulsion takes place while they are yet at a distance from each other and it opposes their approach towards each other.

The cause or the nature of this force is equally inscrutable with that of attraction, but its existence is undoubted; it increases as far as has been ascertained inversely as the square of the distance, consequently at the point of contact it is infinite.

The following experiments will serve to prove the energy of repulsion more fully.

Experiment I.

We have seen (experiment III. p. 23) that when a glass tube is immersed in water the fluid is attracted by the glass and drawn up into the tube; but if we substitute mercury instead of water we shall find a different effect. If a glass tube of any bore be immersed in this fluid it does not rise, but the surface of the mercury is considerably below the level of that which surrounds it.

In this case therefore a repulsion takes place between the glass and the mercury which is even considerably greater than the attraction existing between the particles of the mercury, and hence the latter cannot rise in the tube, but is repelled, and becomes depressed.

Experiment II.

When we present the north pole of a magnet A, to the same pole of another magnet B, suspended on a pivot, and at liberty to move, the magnet B, will recede as the other approaches; and by following it with A, at a proper distance, it may be made to turn round on its pivot with considerable velocity

In this case there is evidently some agency which opposes the approach of the north poles of A and B, which acts as an antagonist, and causes the moveable magnet to retire before the other. There is therefore a *repulsion* between the two magnets, a repulsion which increases with the power of the magnets; which may be made so great that all the force of a strong man is insufficient to make the two north poles touch each other...The same repulsion is equally obvious on electrical bodies, for instance,

Experiment III.

If two small cork balls be suspended from a body with silk threads so as to touch one another, and if we charge the body in

SECT I.

INSTANCES OF CORPUSCULAR ATTRACTION.

THE simplest case of the exertion of corpuscular attraction is that, where two bodies placed in mutual contact with each other form a direct union, without changing their chemical properties.

EXPERIMENT I.

If different particles of sulphur be melted together, they form an uniform mass or whole, the particles of which are held together by virtue of the power of corpuscular attraction, but the properties of the body are not altered.

The same effect takes place when pieces of the same metal, or particles of resin, wax, &c. are united in a similar manner.

Innumerable other instances might be advanced, were not the subject obvious to every one.

MEASUREMENT OF CORPUSCULAR ATTRACTION.

The force of corpuscular attraction in solid bodies may be measured by the weight necessary to demolish it. Thus if a rod of metal, glass, wood, &c. be suspended in a perpendicular direction, and weights be attached to its lower extremity till the rod is broken by them, the weight attached to the rod just before it broke is the measure of the cohesive force of the rod.

SECT. II.

GENERAL LAWS

OF

CORPUSCULAR ATTRACTION.

LAW I....*The agency of corpuscular attraction acts only at insensible distances; its force* INCREASES *as the distance of the bodies presented to each other* DECREASES, *and as the surfaces of apparent contact are more numerous.*

EXPERIMENT I.

IF we take two sections of a leaden ball, having each a flat and smooth surface, and press them forcibly together, they will ad-



faces touch each other in many points. It has been noticed that a silk-worm's thread can be interposed, but not two.

The pressure of the atmosphere has no influence on these experiments, for they succeed equally well in vacuo as in the open air.

It is on this account that carpenters, when they intend to glue pieces of wood together, plane the surfaces perfectly smooth before they apply the glue; and that the surfaces of metals are scraped clean before they are soldered, &c.

Hence the corpuscular attraction always vanishes whenever the distance is measurable, and becomes exceedingly great whenever the distance is exceedingly diminished, but the particular rate which this power follows is still unknown, as we have no method of measuring either the distance at which it acts, or its relative intensity.

LAW II....*Corpuscular attraction acts differently in different bodies; according to the degree of force with which it acts between the particles of matter, the bodies appear under different forms.*

1. It is on this account that rock-crystal, flint, diamond and various other precious stones are extremely hard, for the corpuscular attraction unites the particles of these bodies with a great degree of force. Hence a considerable mechanical effort is necessary to disunite them.

2. In blocks of marble, chalk, lime-stone, &c. the particles are held together with a force considerably less. In these bodies it prevents all relative motion among the particles themselves, and hence the motion of one particle is followed by the motion of the whole mass; or if that is impossible, the cohesion is destroyed altogether, and the piece breaks.

3. The integrant parts of wax, tallow, suet, or lard, may made to change their situations, with a less degree of force th the former.

In these substances the motion of one particle of the bo is not necessarily followed by that of all the rest, neither does th motion destroy the cohesion, nor break them.

4. The particles of water, spirit, and ether, move or slide ov each other very readily; hence their resistance is considerab less.

5. And lastly, vapours, the air of the atmosphere, and all t gases yield to the slightest possible impulse.

LAW III...*Corpuscular attraction may be annihilated by eve effort which tends to separate the particles of bodies.*

It need hardly be mentioned that all mechanical forces, suc as grinding, cutting, filing, rasping, pounding, breaking, &c. a of this nature.

ON

THE NATURE

OF

CHEMICAL AFFINITY,

OR

AFFINITY OF COMPOSITION.

PART VII.

SECT. I.

THEORY OF CHEMICAL AFFINITY.

AFFINITY of composition, or chemical affinity, is that power, by means of which the particles of bodies, whether simple or compound, attract each other so intimately as to produce an uniform whole, totally inseparable by mechanical efforts, and whose characteristic properties are often different, and sometimes contrary to those of its constituent parts.

It is obvious from this, that the particles of those bodies which are united by virtue of chemical affinity, form not a mere aggregate, but an entire new body, which can only be altered by the action of another chemical power.

In considering this kind of affinity, it will be necessary to state;

In what manner it takes place between the particles of different bodies;

In what proportion they are capable of combining;

Under what conditions;

With what degree of force they unite;

And what takes place when a variety of different substances are made to act upon each other at the same time, under certain circumstances and in different proportions.

Hence affinity of composition is of greater importance than corpuscular attraction, or affinity of aggregation, for it takes place in all the complex operations of chemistry.

These topics will form the subject of the following sections.

SECT. II.

INSTANCES OF CHEMICAL AFFINITY.

TO prove that chemical affinity acts differently from attraction of aggregation; that it takes place between the ultimate constituent parts of bodies; and that it produces substances possessing properties, frequently very different, and sometimes contrary to those of the constituent parts, the following experiments may serve.

EXPERIMENT I.

Formation of sulphuret of mercury.

Put into a crucible placed in a coal fire, equal parts by weight of sulphur and mercury; stir the two substances together for a few minutes, and when the sulphur is melted, pour the contents out on a marble slab, or piece of glass previously warmed and greased.

The substance obtained by this means is a *sulphuret of mercury*, in which the mercury and sulphur are united by virtue of chemical affinity; for the compound has neither the colour, the splendour, the inflammability, the volatility, nor the specific gravity of either of its constituent parts; nor can the sulphur and mercury be separated by mechanical means; they are therefore chemically united.

A solid alloy of mercury and bismuth, and another compound of lead and mercury, on being triturated together instantly become fluid.

It is obvious from this, that when chemical combination takes place, the compound which is formed does not possess properties merely intermediate between those of its component parts, but acquires others more or less new. This however does not always hold good in all cases. There are various combinations in which the properties of bodies are only slightly altered.



Experiment V.

Two odorous and pungent bodies produce a compound destitute of odour.

(Formation of muriate of ammonia.)

Water impregnated with ammonia and concentrated muriatic acid, both fluids of a strong odour, when mixed together in proper proportions, instantly lose their odour, and form a fluid void of smell, (muriate of *ammonia.*)

Experiment VI.

Two fluid bodies produce a solid, when mingled together.

(Formation of sulphate of lime.)

Into a saturated solution of muriate of lime, let fall gradually concentrated sulphuric acid, a quantity of pungent vapour will become disengaged, (muriatic acid gas,) and from the two fluids will thus be produced an almost solid compound, called sulphate of lime.

Experiment VII.

Two solid bodies produce a fluid, by mere mixture.

Let equal parts of fresh crystallized acetite of lead and acidulous sulphate of alumine and potash, be rubbed together intimately in a stone mortar, the saline mixture will soon become soft, and lastly fluid.

A like effect is produced by treating in a similar manner equal parts of crystallized nitrate of ammonia and sulphate of soda.

[redacted]

[redacted]

[redacted]

SECT. IV.

EXPERIMENTAL PROOFS

OF

THE LAWS OF CHEMICAL AFFINITY.

w 1...Chemical affinity can exert its action between a number of bodies, simple or compound, and unite them chemically into one whole.

PROOFS OF LAW I.

THERE are an infinite variety of compounds, consisting of ree, four, five or more simple substances in nature; and art can so effect combinations in which there are many simple bodies emically united into one whole.

It frequently happens that various separate bodies presented to ch other in a fluid, unite and form a single mass, which pos-sses all the characters of an homogeneous compound, and which tains these characters till its composition has been altered by emical means.

A considerable number of triple salts are known, which consist three different substances; for instance, the common alum of mmerce consists of sulphuric acid united to alumine and potash soda. The salt formerly called microcosmic salt or phosphate soda and ammonia, consists of phosphoric acid united to soda. d ammonia, &c. When the oxigenated muriate of mercury is ecipitated by the precise quantity of carbonate of soda which is quisite to effect its decomposition, the precipitate obtained ntains muriatic acid, carbonic acid, and oxid of mercury in cess.

Experiment I.

antity of dry carbonate of soda and tartareous acid
gether, and put the mixture into a wine-glass, no
nge will be produced; but if water be added, or ei-
salts be previously dissolved, a violent effervescence
a chemical union is obtained.
r added is of use merely to overcome the resistance
s from the cohesion of the particles of the salts in-
be brought into the sphere of action, or to increase
al contact.

Experiment II.

et fall a crystal, or lump of fluor spar (fluate of lime)
entrated sulphuric acid, no sensible action will take
th the sulphuric acid and the fluate of lime remain un-
but if the former be reduced to powder, and then
into contact with the acid, a considerable action instantly
ace, the sulphuric acid unites to one of the constituent
the fluor spar, namely, to the lime, and its other con-
t part, the fluoric acid, becomes disengaged in the state
te vapour, or fluoric acid gas.

Experiment III.

crystalized sulphate of alumine, or sulphate of soda, and ace-
f lead are brought into contact with each other, the indivi-
y of these bodies will not be destroyed, that is to say, no
ical change will take place; but if they be intimately rubbed

together in a mortar, the two solids will act upon each other and form a fluid.

It is obvious therefore that in order to facilitate chemical affinity, the attraction of aggregation must be broken; the bodies intended to be chemically united must not be presented to each other in their mass of contact, but mechanically divided, or reduced to the smallest moleculæ possible.

Hence liquids combine with more facility than solids, or even than a solid and a liquid, and in like manner vapours combine with rapidity and ease.

Law III....*The agency of affinity of composition is influenced by temperature. Its action is either accelerated, retarded, prevented, or rendered efficacious.*

PROOFS OF LAW III

Experiment I.

If we expose phosphorus in an open vessel to the action of the atmosphere, a chemical union will take place between the phosphorus and one of the constituent parts of the atmosphere, namely, the oxigen gas; the phosphorus will gradually (but very slowly) disappear, and become converted into a fluid called phosphorous acid.

But if we heat the vessel containing the phosphorus, the latter will take fire, and become converted into a yellowish white substance, which in a short time is changed into an acid analogous to the former.

Experiment II.

If equal quantities of muriate of ammonia and carbonate of magnesia are mixt with six or eight parts of water, and suffered to stand for some time exposed to the ordinary temperature of the atmosphere, a mutual decomposition of the two salts will

take place. For if the mixture, and the fluid which passes are left to evaporate spontaneously, muriate of magnesia and carbonate of ammonia will be obtained.

On the contrary,

Experiment III.

If equal quantities of muriate of magnesia and carbonate of ammonia be exposed to a temperature of 200° in about four parts of water, the products obtained are, muriate of ammonia and carbonate of magnesia.

Experiment IV.

If muriate of soda and sulphate of magnesia be mixed together in any proportion, and exposed to a temperature below *zero*, they decompose each other, and muriate of magnesia and sulphate of soda are formed, but no decomposition takes place at a temperature above 30°.

Muriate of soda and acidulous sulphate of alumine and potash, exhibit precisely the same phenomena.

Experiment V.

If ardent spirit and a solution of salt in water be mixt together, the compound formed is a real chemical union; but if we carefully heat the fluid, the caloric applied will be divided between the three ingredients according to their respective affinities; the union will be broken, for the ardent spirit will first become volatilized, and the union of the salt and water remain unaltered. On increasing the temperature, the water will escape in the form of vapour, and the salt will be left behind.

There are numerous cases in which an increase of temperature is essentially necessary to determine bodies to unite. If mercury be exposed to oxigen gas at the common temperature of the atmosphere, the corpuscular attraction subsisting between

higher degree of temperature, the union is demolished, and
quickness to appears in a gaseous state

However a certain degree of caloric favors the u
of the ex
of the
this d
bumper crop.

This principle explains the power of chem
union, the solvent powers of air and water afford instances of.

A larger quantity of salt is soluble in a given quantity of
ter at a high, than at a low temperature, and this larger quan
of salt is again separated by cooling

Law IV.—*Chemical affinity is accompanied by a change of te
peculiar to the nature of the action.*

The truth of this principle will be perceived by applyi
experiment to theory.

PROOFS OF LAW IV.

gether, the mixture in a few minutes becomes so hot as to render the vessel insupportable to the hands.

If four parts of sulphuric acid of commerce, and one part by weight of water, be mixed together, each at the temperature of 50°, the mixture immediately acquires a temperature of about 300°.

All the dense acids, ammonia, and ardent spirit, when mixed with water, have the property of raising its temperature remarkably: and the same is the case when alcalis are introduced into concentrated acids. On the contrary, in many instances cold is produced.

Experiment II.

Production of extreme degrees of cold.

Take one ounce and a half of muriate of ammonia, and a like quantity of nitrate of potash; reduce each of these salts separately to a powder, and blend them intimately together: having done this, mix them gradually in a glass bason, or other thin glass vessel, with four ounces of water. The result will be, that the cold produced will sink a thermometer immersed in it, to 36° Fahr: A new addition of the same quantity of salts will cool it to 14°, which therefore will freeze water in a glass tube that is immersed in it, without the use of snow or ice. If the water used in a first process be used to reduce other water and salts to the temperature of about 32°, and these be applied to the performance of a second experiment, the temperature may be lowered to 4° below 0°.

A number of experiments have lately been made to produce artificial cold by means of such freezing mixtures. The most complete set of this kind are those of Pepys, Lowitz and Walker. They shall be noticed in the next part of this work.

LAW V...*The agency of chemical affinity between two or more bodies may lie dormant, until it is called into action by the interposition of another body, which frequently exerts no energy upon any of them in a separate state.*

From this law originates what was formerly called disposing affinity, or that case in which two or more bodies are incapable of uniting, until the agency is called into action by the addition of a third body, which exerts no sensible affinity upon either of them.

This may be proved in the following manner.

PROOFS OF LAW V.

Water is a compound of hidrogen and oxigen; phosphorus is a simple body according to our present state of knowledge. If these be presented to each other, no chemical union will take place; but if we add to them an alcali, and then apply heat, the water will become decomposed; that is to say: part of the phosphorus will unite to the oxigen of the water, and form phosphoric acid, and the other part will be dissolved in the hidrogen gas and appear as phosphorated hidrogen.

Here the alcali acts as the substance requisite to favor the mutual action, or to give the disposing affinity.

If iron and water be brought into contact with each other, no perceptible change will be produced; but if a little sulphuric acid be added to the water and iron, a violent effervescence will take place, the water will become decomposed, hidrogen gas will be evolved, and the iron become dissolved in the acid.

In this case the sulphuric acid is the condition necessary to accelerate the chemical action

These experiments will be more fully considered hereafter.

LAW VI....*The ratio of the energy of chemical affinity acting between various bodies, is different in different substances.*

This is the most important law of chemical attraction. As beginners will find it rather difficult to understand what passes in this more complicated agency, we shall shortly remark, that the combination which is effected between two or more bodies by virtue of the affinity of composition, becomes broken whenever we present to the compound another body, which has an attraction to one of the constituent parts of the compound, superior to that attraction by which they were held together: the bodies therefore between which the strongest attraction prevails combine, and the rest are disengaged.

PROOFS OF LAW VI.

EXPERIMENT I.

If muriatic acid be poured either on pure barytes, or on its carbonate, the barytes will be dissolved and the compound will be muriate of barytes, which compound is held together by the force of affinity existing between the muriatic acid and the barytes. On letting fall into this solution a few drops of sulphuric acid, an immediate change of principles takes place; the whole quantity of the muriatic acid which was combined with the barytes becomes disengaged, and the sulphuric acid unites to the barytes with a force equal to their affinity, *minus* that of the muriatic acid.

EXPERIMENT II.

If pure silver be dissolved in pure nitric acid, the silver will remain united to the acid, till another body is presented to it

which has a greater force of attraction to one of the constituent parts of the compound; for instance; if mercury be added to this solution of silver, the mercury will be dissolved, and the silver becomes precipitated or disengaged. The supernatant fluid will then be a *solution of mercury in nitric acid.*

Experiment III.

If to the before obtained solution of mercury in nitric acid, a piece of sheet lead be presented, the lead will be dissolved, and the mercury become precipitated. The fluid will then be a *solution of lead in nitric acid.*

Experiment IV.

If in this solution of lead, a thin slice of copper be suspended, the copper will be dissolved, and the lead will become disengaged. The fluid now is a *solution of copper in nitric acid.*

Experiment V.

If in this solution of copper, a thin sheet of iron be kept immersed, the iron will be dissolved, and the copper becomes precipitated. The fluid now is a *solution of iron in nitric acid.*

Experiment VI.

If to this solution of iron, a piece of zinc be presented, the zinc will be dissolved, and the iron become precipitated. The solution then consists of *zinc and nitric acid.*

Experiment VII.

If to this solution of zinc in nitric acid some ammonia be gradually added, the ammonia will join to the acid, and the zinc will be precipitated. The solution will then be *nitrate of ammonia.*

Experiment VIII.

If to this solution of nitrate of ammonia, some lime water be added, the ammonia will become disengaged (and manifest itself by a pungent odour) and the solution will be *nitrate of lime.*

Experiment IX.

If to this solution of nitrate of lime some oxalic acid be added, the lime will be precipitated, and what now remains will be merely *nitric acid.*

We see from these experiments that different bodies have different degrees of affinity for one and the same substance, which can only be learnt from observation and experiments.

Remarks...It appears nevertheless from Berthollet's Treatise, as we shall see directly, that in almost all cases of elective affinity, there is not a total transfer of the base, but that a division is made between the two opposite attracting substances, in a compound ratio of the relative force of affinity, and quantity of each; that in many cases the excess of quantity, may supply the deficiency of force, and therefore that the *mass* must be carefully taken into consideration.

Law VII....*The agency of chemical affinity is either limited or unlimited; in other words, chemical affinity is capable of uniting bodies in definite, or in indefinite proportions.*

Experience has convinced us that in all bodies there are certain precise limits of combinations beyond which their action cannot pass, namely a *minimum*, and a *maximum*; it remains still to be ascertained how bodies can combine within these limits.

If we attend to what is known at present, we are forced to acknowledge that this law comprehends several modifications, which may be arranged under the following classes.

1. Chemical affinity unites several bodies in any proportion whatsoever, their combination is therefore unlimited, for instance,

PROOFS OF LAW VII.

Experiment I.

If water and ardent spirit be mingled together in any quantity, a chemical combination ensues, for the compound obtained has always a specific gravity different from the mean specific gravity of the fluids combined. Its bulk is likewise not the arithmetical mean of the fluids in a separate state.

The same is the case when liquid acids and water, or acids and ardent spirit are combined together.

2. Chemical affinity combines several bodies to a certain extent or *maximum* only.

To this class belong all those bodies which are capable of (what is called) saturation.

Experiment II.

If we take a quantity of any of the dense acids diluted with water, for instance sulphuric acid, and let fall into it a solution of an alcali, for example soda, by a little at a time, and examine the mixture after every addition of the alcali, we find for a considerable time it will exhibit the properties of an acid, it will have a sour taste, and convert vegetable blue colours into red; but if we continue to add greater quantities of soda, these acid properties will gradually diminish, and at last disappear altogether. At that point the combination is at an end, it has reached its *maximum* in this case; for if we continue to add more alcali, the mixture will gradually acquire alcaline properties; it

will convert blue vegetables into green; it will have an urinous or alcaline taste, &c. These properties will become stronger the greater the quantity of the soda is which is added.

Experiment III.

Take muriatic acid and let fall into it gradually carbonate of lime or magnesia; an effervescence will take place, for a chemical union ensues between the acid and the lime, or magnesia, and the carbonic acid the other constituent of these bodies, becomes disengaged. But if we continue the addition of the lime or magnesia, until it produces no further effervescence, no chemical union will be obtained, the lime will fall to the bottom unaltered, for the combination is at its *maximum*.

It is on this account that water can only dissolve a certain quaintity of salt; ardent spirit a certain quantity of resin, &c.

The union of oxigen and hidrogen, belongs likewise to this class.

3. Chemical affinity is capable of uniting different bodies in two, three or more proportions; each of these combinations produces compounds possessing peculiar properties.

This peculiarity of combination is highly important.

It is owing to this circumstance that both nature and art produce substances of the same principles only combined in different proportions, which possess peculiar properties widely different from each other.

An instance of this law may be seen in the following

Experiment IV.

Introduce one ounce of copper filings into four ounces of muriatic acid contained in a medicine phial of eight ounces capacity, cork it well and let it stand undisturbed; the acid will soon acquire a greenish colour, which becomes deeper in

to determine the elective affinity of different bodies to each
it is requisite to enquire what are the phenomena which
offer when presented to each other in different propor
These phenomena have hitherto been little attended to; n
much attention been paid to other particular circumstances
appear capable of influencing the agency of affinity in ge
namely: the action of light, electricity, galvanism, &c.

When these, and the before-mentioned discovery of Bert
for determining the relative strength of affinity are more att
to, they will probably lead to consequences of the greatest im
ance. It will oblige chemists to attend more closely to the
procal action of bodies on each other under different cir
stances, and the result must be, the discovery of several
which will greatly facilitate the acquisition and the adv
ment of the science.

The rapid progress which chemistry has lately made; the
tiplicity of its researches; and the scrupulous accuracy o
servation with which experiments are now conducted affo
every reason to hope that this will soon be accomplished.

HEAT,

—OR

CALORIC.

PART VIII.

HEAT and cold are perceptions of which we acquire the ideas from the senses; they indicate only a certain state in which we find ourselves independent of any exterior object. But as these sensations are for the most part produced by bodies around us, we consider them as causes, and judging by appearances, we apply the terms *hot*, or *cold*, to the substances themselves; calling those bodies *hot*, which produce in us the sensation of heat, and those *cold*, which communicate the contrary sensation.

This ambiguity, though of little consequence in the common affairs of human life, has led unavoidably to confusion and perplexity in philosophical discussions. It was to prevent this, that the framers of the new nomenclature adopted the word CALORIC, which denotes that which produces the sensation of heat.

caloric of temperature, interposed caloric, &c. expressions now pretty generally superseded.

From the diversity of opinions among chemists respecting the nature of caloric several other expressions have been introduced, which it is proper to notice. For instance, by *specific heat* is understood the relative quantities of caloric contained in equal weights of different bodies at the same temperature. *Latent heat* is the expression used to denote that quantity of caloric which a body absorbs when changing its form. It is however more properly called *caloric of fluidity*. The disposition, or property by which different bodies contain certain quantities of caloric, at any temperature, is termed their *capacity for heat*. By the expression of *absolute heat*, is understood the whole quantity of caloric which any body contains. These terms shall be more fully considered hereafter.

Before we proceed further we shall briefly notice the various methods of exciting heat, and then endeavour to examine its general properties.

SECT. II.

METHODS OF EXCITING AND COLLECTING HEAT.

OF the different methods of exciting heat, the following are the most usual:

1. PRODUCTION OF HEAT BY PERCUSSION OR COLLISION.

This method of producing heat is the simplest, and therefore it is generally made use of in the common purposes of life for obtaining fire.

When a piece of hardened steel is struck with a flint, some particles of the metal are scraped away from the mass, and so violent is the heat which follows the stroke, that it melts and vitrifies them. If the fragments of steel are caught upon paper and viewed with a microscope, most of them will be found perfect spherules, and very highly polished. Their sphericity demonstrates that they have been in a fluid state, and the polish upon their surface shows them to be vitrified.

No heat however has been observed to follow the percussion of liquids, nor of the softer kind of bodies which yield to a slight impulse.

2. PRODUCTION OF HEAT BY FRICTION.

Heat may likewise be excited by mere friction. This prac is still retained in some parts of the world. The natives of N Holland are said to produce fire in this manner with great cility, and spread it in a wonderful manner. For that purp they take two pieces of dry wood, one is a stick about ei or nine inches long, and the other piece is flat; the stick th shape into an obtuse point at one end and pressing it upon other piece, they turn it very nimbly by holding it between bo hands as we do a chocolate mill, often shifting their hands and then moving them down upon it in order to increase th pressure as much as possible. By this method they get fire in few minutes and from the smallest spark they increase it wi great speed and dexterity.

If the irons at the axis of a coach-wheel are applied to eac other without the interposition of some unctuous matter to kee them from immediate contact, they will become so hot whe the carriage runs swiftly along as to set the wood on fire; an the fore-wheels being smallest and making most revolutions in given time will be most in danger.

The same will happen to mill-work or to any other machinery

It is no uncommon practice in this country for blacksmiths to use a plate of iron as an extemporaneous substitute for a tinder-box; for it may be hammered on an anvil till it becomes red hot, and will fire a brimstone match. A strong man who strike quick and keeps turning the iron so that both sides may be equally exposed to the force of the hammer, will perform this in les time than would be expected.

If in the coldest season one dense iron plate be laid on another and pressed together by a weight, and then rubbed upon each

other by reciprocal motions, they will gradually grow so hot as in a short time to emit sparks and at last become ignited.

It is not necessary that the substances should be very hard, a cord rubbed backwards and forwards swiftly against a post or a tree will take fire.

Count Rumford* and professor Pictet† have made some very ingenious and valuable experiments concerning the heat evolved by friction.

3. PRODUCTION OF HEAT BY CHEMICAL ACTION.

To this belongs the heat produced by combustion. There are besides this many chemical processes wherein rapid chemical action takes place accompanied with a development of heat, or fire and flame. Instances of this kind have been noticed already, page 19. More striking experiments will be given in the progress of this work.

4. SOLAR HEAT.

It is well known that the solar rays when collected by a mirror or lens into a focus produce the most astonishing effects.

Dr. Herschell has discovered that there are rays emitted from the sun, which have not the power of illuminating or producing vision; and that these are the rays which produce the heat of the solar light.

Consequently heat is emitted from the sun in rays, but these rays are not the same with the rays of light, as shall be more fully proved hereafter.

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* Nicholson's Journal (4th Edit.) Vol. II. p. 106.

† Pictet's Essais sur le Feu. Chap. ix.

The effects of electricity are too well known in this pe
view to need any description.

Galvanism has of late become a powerful instrument f
purpose of exciting heat. Not only easily inflammable sul
ces such as phosphorus, sulphur, &c. have been fired, but
wise, gold, silver, copper, tin and the rest of the metal
been burnt by means of galvanism, as was shown by pro
Davy in his lectures at the theatre of the Royal Insti
in 1801.

Such are the principal methods of exciting heat. We shal
endeavour to examine experimentally the effects which hea
duces upon bodies in general.

SECT. III.

GENERAL EFFECTS OF HEAT.

EXPANSIVE PROPERTY OF HEAT.

THIS is the first and most obvious effect which heat produces on bodies. Experience has taught us that at all times when bodies become hot, they increase in bulk. The bodies experience a dilatation which is greater in proportion to the accumulation of caloric, or in other words, to the intensity of the heat. This is a general law which holds good as long as the bodies have suffered no change either in their combination or the quantity of their chemical principles.

This power which heat possesses consists therefore in a constant tendency to separate the particles of bodies. Hence philosophers consider heat as the *repulsive power* which acts upon all bodies whatever, and which is in constant opposition to the power of attraction.

The phenomena which result from these mutual actions seem as it were the secret springs of nature. Heat however does not expand all bodies equally, and we are still ignorant of the laws which it follows.

1. EXPANSION OF FLUID BODIES BY HEAT.

Experiment I.

Take a glass globe with a long slender neck (called a bolt head) fill it up to the neck with water, ardent spirit, or any other fluid which may be coloured with red or black ink in order to be

more visible and then immerse the globe of the instrument in a vessel of hot water; the included fluid will instantly begin to mount into the neck. If it be taken out of the water and brought near the fire, it will ascend more and more in proportion as it becomes heated; but upon removing it from the source of heat, it will sink again: a clear proof that caloric dilates it, so as to make it occupy more space when hot, than when cold. These experiments may therefore serve as a demonstration that heat expands *fluid* bodies.

It appears that liquids of the least density expand most with the same temperature. Thus hidrogen gas dilates more with the same degree of heat than atmospheric air; atmospheric air more than sulphuric ether; ether more than ardent spirit; ardent spirit more than oil; oil more than water; water more than acids, and acids more than mercury. But if we compare the periods of time necessary for each fluid to acquire the *maximum* of rarefaction it is susceptible of, there is no law to guide us yet known.

2. EXPANSION OF AERIFORM BODIES BY HEAT.

Experiment I.

Take a bladder partly filled with air, the neck of which is closely tied, so as to prevent the inclosed air from escaping, and let it be held near a fire. The air will soon begin to occupy more space, and the bladder will become gradually distended; on continuing the expansion of the air by increasing the heat, the bladder will burst with a loud report.

3. EXPANSION OF SOLID BODIES BY HEAT.

Experiment I.

If we take a bar of iron six inches long and put it into a fire till it becomes red-hot; and then measure it in this state accurately, it will be found $\frac{1}{10}$ of an inch longer than it was before; that

is about 120th part of the whole. That the metal is proportionally expanded in breadth, will be seen by trying to pass it through an aperture which it fitted exactly when cold, but which will not admit it when red-hot. The bar is therefore increased in length and diameter.

To discover the minutest changes of expansion by heat, and the relative proportions thereof, instruments have been contrived called *Pyrometers*, the sensibility of which is so delicate as to show the expansion from $\frac{1}{50000}$ to $\frac{1}{100000}$ of an inch.

INFERENCES.

It is owing to this expansion of metals, that the motion of time-pieces is rendered erroneous; but the ingenuity of artists has discovered methods of obviating this inaccuracy, by employing the greater expansion of one metal to counteract the expansion of another; this is effected in what is called the gridiron pendulum. Upon the same principle a particular construction of watches has been contrived.

The expansion of metals is likewise one of the principal reasons that clocks and watches vary in winter and summer, when worn in the pocket, or exposed to the open air, or when carried into a hotter or a colder climate. For the number of the vibrations of the pendulum, are always in the sub-duplicate ratio of its length, and as the length is changed by heat and cold, the times of vibration will be also changed. The quantity of alteration when considered in a single vibration is exceedingly small, but when they are often repeated it will be very sensible. An alteration of one thousandth part in the time of a single vibration of a pendulum which beats seconds, will make a change of eighty-six whole vibrations in twenty four hours.

As different metals expand differently with the same degree of heat; such musical instruments therefore whose parts are to maintain a constant true proportion, should never be strung with

not expand in the same ratio, and are therefore torn asun
break. Hence thin vessels stand heat better than thick one

SECT. IV.

MEASUREMENT OF HEAT.

UPON the expansive property of heat, which we have considered before, is founded its artificial measurement. Various means have been therefore employed to assist the imperfection of our sensations in judging of the different degrees of heat, for our feelings unaided afford but very inaccurate information concerning this matter; they indicate the presence of *heat*, only when the bodies presented to them are *hotter* than the actual temperature of our organs of feeling. When those bodies are precisely of the same temperature with our body, which we make the standard of comparison, we then are not sensible of the presence of heat in them. When their temperature is less hot than that of our bodies their contact gives us what is called the sensation of cold.

The effects of heat upon material bodies in general which are easily visible to us, afford more precise and determinate indications of the intensity, than can be derived from our feelings alone. The ingenuity of the philosopher and artist, has therefore furnished us with instruments for measuring the relative heat or temperature of bodies. These instruments are called *Thermometers* and *Pyrometers*. By these all degrees are measurable, from the slightest, to that of the most intense heat.

1. NATURE OF THE THERMOMETER.

A thermometer is a hollow tube of glass, hermetically sealed and blown at one end in the shape of a hollow globe. The

bulb and part of the tube are filled with mercury, which is the only fluid which expands equally. When we immerse the bulb of the thermometer in a hot body, the mercury expands, and of course *rises* in the tube; but when we plunge it into a cold body the mercury contracts and of course *falls* in the tube.

The rising of the mercury indicates therefore an increase of heat; its falling a diminution of it; and the quantity which it rises or falls, denotes the proportion of increase or diminution. To facilitate observation the tube is divided into a number of equal parts, called degrees.

Further, if we plunge a thermometer ever so often into melting snow or ice, it will always stand at the same point. Hence we learn *that snow* or *ice* always begins to melt at the same temperature.

If we plunge a thermometer repeatedly into water kept boiling, we find that the mercury rises up to a certain point. This is therefore the point at which water always boils, provided the pressure of the atmosphere be the same.

There are four different thermometers used at present in Europe, differing from each other in the number of degrees into which the space between the freezing and boiling points is divided. These are Fahrenheit's, Reaumur's, Celsius's, and Delisle's.

The thermometer uniformly used in Britain, is Fahrenheit's; in this the freezing point is fixed at 32°....the boiling point, at 212° above 0°...or the part at which both the ascending and descending series of numbers commence.

In the thermometer which was first constructed by Reaumur, the scale is divided into a smaller number of degrees upon the same length, and contains not more than 80° between the freezing and the boiling points. The freezing point is fixed in this thermometer precisely at 0°, the term between the ascending and the descending series of numbers. 100 is the number of the degrees between the freezing and the boiling points in the

scale of Celsius; which has been introduced into France since the revolution under the name of the Centigrade thermometer; and the freezing point is in this as in the thermometer of Reaumur fixed at 0°. One degree on the scale of Fahrenheit, appears from this account to be equal to $\frac{4}{9}$ of a degree on that of Reaumur, and to $\frac{5}{9}$ of a degree on that of Celsius.

The space in Delisle's thermometer between the freezing and boiling points is divided into 150°, but the graduation begins at the boiling point and increases towards the freezing point. The boiling point is marked 0, the freezing point 150°. Hence 180 F: = 150 D, or 6 F: = 5 D. To reduce the degrees of Delisle's thermometer *under* the boiling point to those of Fahrenheit; we have F: $= 212 - \frac{6D}{5}$; to reduce those *above* the boiling point F: $= 212 + \frac{6D}{5}$. Upon the knowledge of this proportion it is easy for the student to reduce the degrees of any of these thermometers into the degrees of any other of them.

2. NATURE OF THE PYROMETER.

To measure those higher degrees of heat to which the thermometer cannot be applied, there have been other instruments invented by different philosophers, these are called *pyrometers*. The most celebrated instrument of this kind, and which has been adopted into general use, is that invented by the late ingenious Mr. Wedgwood.

This instrument is also sufficiently simple. It consists of two pieces of brass fixed on a plate so as to be $\frac{6}{10}$ of an inch asunder at one end, and $\frac{3}{10}$ at the other; a scale is marked upon them which is divided into 240 equal parts, each $\frac{1}{10}$ of an inch; and with this his gauge, are furnished a sufficient number of pieces of baked clay, which must have been prepared in a red heat, and must be of given dimensions. These pieces of clay, thus prepared, are first to be applied cold, to the rule of the gauge, that there may no mistake take place in regard to their dimensions. Then any one of them is to be exposed to the heat which is to

High temperatures can thus be ascertained with acc
Each degree of Wedgwood's pyrometer is equal to 1
Fahrenheit's.

SECT. V.

EXCEPTIONS TO THE EXPANSION BY HEAT.

PHILOSOPHERS have noticed a few exceptions to the law of heat expanding bodies. For instance; water when cooled down to the freezing point, instead of contracting on the farther deprivation of heat, actually expands.

Another seeming exception is manifested in alumine or clay; others occur in the case of cast-iron, and various other metals. Alumine contracts on being heated, and cast-iron, bismuth, &c. when fully fused are more dense than when solid, for as soon as they become so, they decrease in density, they expand in the act of cooling, and hence the sharpness of figures upon iron which has been cast in moulds, compared to that of other metals.

Some philosophers have persuaded themselves that these exceptions are only *apparent*, but not really true. They say when water freezes, it assumes a crystalline form, the crystals cross each other and cause numerous vacuities, and thus the ice occupies more space. The same is the case with fused iron, bismuth, and zinc. The contraction of clay is owing to the loss of water, of which it loses a part at every increased degree of temperature hitherto tried; there is therefore a loss of matter; and a reduction of volume must follow.

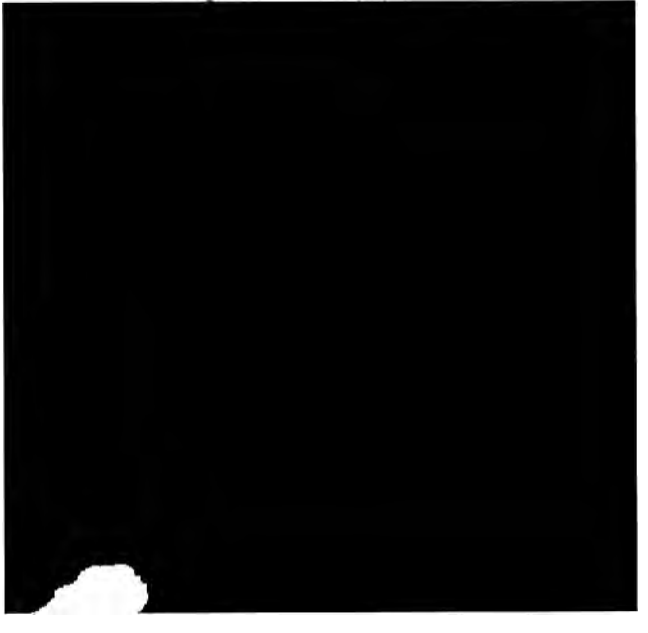
Mr. Tilloch* has published a brief examination of the received doctrines respecting heat and caloric, in which these truths are more fully considered, together with many other interesting facts relative to the received notions of heat.

* Philosophical Magazine, May 1800, p. 78.

SECT. VI.

EQUAL DISTRIBUTION OF HEAT.

IF a number of bodies of different temperatures are place contact with each other, they will all at a certain time ac a temperature, which is the mean temperature of the diff substances; the caloric of the hottest body will diffuse itself an those which are heated in a less degree, till they have all ac ed a certain temperature. Thus if a bar of iron which been made red-hot be kept in the open air, it does not retain heat which it had received but becomes gradually colder colder, till it arrives at the temperature of the bodies in its n bourhood. On the other hand; if we cool down the iron b keeping it for some time covered with snow, and then ca into a warm room, it does not retain its low temperature, becomes gradually hotter till it acquires the temperature



SECT. VII.

PROPAGATION OF HEAT.

WE have seen in the last section that when bodies of higher temperature than others are brought into contact with each other the heat is propagated from the first to the second, or the colder body deprives the warmer of its excess of heat.—We shall now see that some bodies do so much more quickly than others. Through some bodies caloric passes with undiminished velocity, through others, its passage is prodigiously retarded.

This disposition of bodies of admitting under equal circumstances the refrigeration of a heated body within a shorter or a longer time, is called *the power of conducting heat;* and a body is said to be a *better* or *worse conductor of heat,* as it allows the refrigeration to go on quicker or slower. Those bodies therefore which possess the property of letting heat pass with facility are called *good conductors*; those through which it passes with difficulty are called *bad conductors,* and those through which it does not pass at all, are called *non-conductors*: thus we say in the common language, some bodies are *warm* or capable of preserving warmth; and from this arises the great difference in the sensation excited by different bodies, when applied at the same temperature to our organs of feeling. Hence if we immerse our hand in mercury we feel a greater sensation of cold than when we immerse it in water, and a piece of metal appears to be much colder than a piece of wood, though their temperatures when examined by means of the thermometer are precisely the same.

It is probable that all solids conduct heat in some degr
though they differ very much in their conducting power. Met
are the best conductors of heat; but the conducting power
these substances are by no means equal. Stones seem to be
next best conductors. Glass conducts heat very slowly; wo
and charcoal still slower; and feathers, silk, wool, and hair
still worse conductors than any of the substances yet mention
The best conductors of electricity and galvanism are also
best conductors of heat.

Experiment I.

Take a number of straight wires of equal diameters
lengths, but of different metals, for instance, gold, silver, copp
iron, &c. cover each of them with a thin coat of wax or tallow
and plunge their extremities into water kept boiling, or int
melted lead. The melting of the coat of wax will show that cal
ric is more quickly transmitted through some metals than others.
It is on this account also, that the end of a glass rod may b
kept red-hot for a long time or even melted without any incon
venience to the hand which holds the other extremity; though
a similar metallic rod heated in the same manner would very
soon become too hot to be held.

LIQUID AND AERIFORM BODIES CONVEY HEAT B
AN ACTUAL CHANGE IN THE SITUATION O
THEIR PARTICLES.

Count Rumford was the first who proved that fluids in general
and aeriform bodies convey heat on a different principle from th
observed in solids. This opinion is pretty generally admitte
though various ingenious experiments have been made b
different philosophers to prove the contrary. In water for in
stance which is in the strictest sense of the word a perfect non
conductor of heat, the Count has proved that caloric is pro

pagated only in consequence of the motion which is occasioned in the insulated and solitary particles of that fluid.

All fluids are considered strictly speaking in a similar respect as *non-conductors* of caloric. They can receive it indeed from other substances and can give it to other substances, but no particle can either receive it from, or give it to, another particle. Before a fluid therefore can be heated or cooled every particle must go individually to the substance from which it receives or to which it gives out caloric. Heat being therefore only propagated in fluids in consequence of the internal motion of their particles which transport the heat; the more rapid these motions are, the more rapid is the communication of heat. The cause of these motions is the change in the specific gravity of the fluid, occasioned by the change of temperature, and the rapidity is in proportion to the change of the specific gravity of the liquid by any given change of temperature. The following experiment may serve to illustrate this theory.

Experiment I.

Take a thin glass tube eight or ten inches long and about an inch in diameter. Pour into the bottom part for about the depth of one inch, a little water coloured with Brazil-wood or Litmus and then fill up the tube with common water, extremely gently, so as to keep the two *strata* quite distinct from each other. Having done this, heat the bottom part of the tube over a lamp, the coloured infusion will then ascend and gradually tinge the whole fluid; the water in the upper part of the tube may be made to boil, but the colouring matter will remain at the bottom undisturbed. The heat cannot act downwards to make it ascend.

By thus being able to make the upper part of a fluid boil without heating the bottom part, water may be kept boiling for a considerable time in a glass tube over ice without melting it.

Other experiments illustrating the same principle may be found in Count Rumford's excellent essays, especially in essay the 7th, 1797.

To this indefatigable philosopher we are wholly indebted for the above facts: he was the first who taught us that air and water were nearly non-conductors. The results of his experiments which are contained in the above essay are highly interesting; they also show that the conducting power of fluids is impaired by the admixture of fibrous and glutinous matter.

Count Rumford proved that ice melted more than 80 times slower when boiling hot water stood on its surface than when the ice was placed to swim on the surface of the hot water. Other experiments showed that water only eight degrees of Fahrenheit above the freezing point, or at the temperature of forty degrees, melts as much ice in any given time, as an equal volume of that fluid at any higher temperature, provided the water stands on the surface of the ice. Water at the temperature of 41° is found to melt more ice, when standing on its surface, than boiling water.

It becomes further evident from the Count's ingenious experiments, that of the different substances used in clothing, hares fur and eider-down are the warmest; next to these, beavers fur, raw silk, sheep's wool, cotton wool, and lastly lint or the scrapings of fine linen. In fur the air interposed among its particles is so engaged as not to be driven away by the heat communicated thereto by the animal body; not being easily displaced it becomes a barrier to defend the animal body from the external cold.

Hence it is obvious that those skins are warmest which have the finest, longest, and thickest fur; and that the furs of the beaver, otter, and other like quadrupeds which live much in the water; and the feathers of water-fowl are capable of confining the heat of those animals in winter, notwithstanding the coldness of the water which they frequent.

Bears, and various other animals, inhabitants of cold climates, which do not often take the water, have their fur much thicker on their backs, than on their bellies.

The snow which covers the surface of the earth in winter in high latitudes is doubtless designed as a garment to defend it against the piercing winds from the polar regions which prevail during the cold season.

Without dwelling farther upon the philosophy of this truth we must briefly remark that the happy application of this law, satisfactorily elucidates some of the most interesting facts of the œconomy of nature.

SECT. VIII.

THEORY OF CALORIC OF FLUIDITY, OR LATENT HEAT.

THERE are some bodies which when submitted to the action of caloric, dilate to such a degree, and the power of aggregation subsisting among their particles is so much destroyed and removed to such a distance by the interposition of caloric, that they slide over each other in every direction, and therefore appear in a fluid state. This phenomenon is called *fusion*. Bodies thus rendered fluid by means of caloric, are said to be *fused*, or *melted*; and those that are subject to it, are called *fusible*.

The greater number of solid bodies, may, by the application of heat, be converted into fluids. Thus metals may be fused;

loric. Solidity is the natural state of all bodies, and there can be no doubt that every fluid is capable of being rendered solid by a due reduction of temperature; and every solid may be fused by the agency of caloric, if the latter does not decompose them at a temperature inferior to that which would be necessary for their fusion.

CALORIC OF FLUIDITY.

Dr. Black was the first who proved that whenever caloric combines with a solid body, the body becomes heated only, until it is rendered fluid; or that whenever it has acquired the fluid state, its temperature remains stationary, though caloric is continued to be added to it. The same is the case when fluids are converted into the aeriform or vaporous state.

From these facts the laws of latent heat have been inferred. The theory may be illustrated by means of the following experiments:

Experiment I.

If a lump of ice, at a low temperature, suppose at 22°, be brought into a warm room, it will become gradually less cold, as may be discovered by means of a thermometer. After a very short time it will reach the temperature of 32°; (the freezing point) but there it stops. The ice then begins to melt; but the process goes on very slowly. During the whole of that time its temperature continues at 32°; and as it is constantly surrounded by warm air, we have reason to believe that caloric is constantly entering into it; yet it does not become hotter till it is changed into water. Ice therefore is converted into water by a quantity of caloric uniting with it.

It has been found by calculation that one pound of ice in melting absorbs 140° of caloric, the temperature of the water produced still remaining at 32°.

This fact may be proved in a direct manner.

Experiment II.

Take one pound of ice at 32° reduced to a coarse powder, put it into a wooden bowl, and pour over it gradually, one pound of water heated to 172°, all the ice will become melted, and the temperature of the whole fluid, if examined by a thermometer, will be 32°; 140° of caloric are therefore lost, and it is this quantity which was requisite to convert the ice into water.

This caloric has been called *latent caloric*, or rather, caloric of fluidity, because its presence is not measurable by the thermometer.

Dr. Black has also ascertained by experiment, that the fluidity of melted wax, tallow, spermaceti, metals, &c. is owing to the same cause, and Ladriani proved that this is the case with sulphur, alum, nitrate of potash, &c.

We consider it therefore as a general law, that whenever a solid is converted into a fluid, it combines with caloric, and that is the cause of fluidity.

On the sudden transition of solids into fluids, is founded the well known

PRODUCTION OF ARTIFICIAL COLD,

BY MEANS OF

FRIGORIFIC MIXTURES.

A number of experiments have been lately made by different philosophers, in order to produce artificial cold. And as these methods are often employed in chemistry with a view to expose bodies to the influence of very low temperatures, we shall enumerate the different substances which may be made use of for that purpose, and the degrees of cold which they are capable of producing. We are indebted for them to Pepys, Walker, and Lowitz.

TABLE

OF

FREEZING MIXTURES.

Mixtures.	*Thermometer sinks.*
Muriate of ammonia. 5 parts Nitrate of potash.... 5 Water.....16	From 50° to 10°
Muriate of ammonia. 5 parts Nitrate of potash.... 5 Sulphate of soda.... 8 Water.....16	From 50° to 4°.
Sulphate of soda..... 3 parts Diluted nitric acid... 2	From 50° to 3°.
Sulphate of soda.... 8 parts Muriatic acid..... 5	From 50° to 0°.
Snow..... 1 part Muriate of soda..... 1	From 32° to 0°.
Snow or pounded ice. 2 parts Muriate of soda..... 1	From 0° to −5.
Snow or pounded ice. 1 parts Muriate of soda..... 5 Muriate of ammonia & Nitrate of potash.... 5	From −5° to −18°.

TABLE

OF

FREEZING MIXTURES.

Mixtures.	*Thermometer sinks.*
Snow or pounded ice . 12 parts Muriate of soda . . . . . 5 Nitrate of ammonia . . 5	From — 18° to — 25°.
Snow and Diluted nitric acid	From 0° to — 46°.
Muriate of lime . . . . . 3 parts Snow 2	From 32° to —50°.
Potash . . . . . 4 parts	From 32° to —51°

TABLE

OF

FREEZING MIXTURES.

Mixtures.	*Thermometer sinks.*
Diluted sulphuric acid 10 parts Snow..... 8	From — 68° to — 91°.
Nitrate of ammonia.. 1 part Water.....1	From 50° to 4°.
Nitrate of ammonia...1 part Carbonate of soda.... 1 Water.....1	From 50° to 3°.
Sulphate of soda..... 6 parts Muriate of ammonia..4 Nitrate of potash.....2 Diluted nitric acid....4	From 50° to 10°.
Sulphate of soda.....6 parts Nitrate of ammonia.. 5 Diluted nitric acid....4	From 50° to 14°.
Phosphate of soda.... 9 parts Diluted nitric acid....4	From 50° to 12°.
Phosphate of soda.... 9 parts Nitrate of ammonia.. 6 Diluted nitric acid....4	From 50° to 21°.
Sulphate of soda.....5 parts Diluted sulphuric acid 4	From 50° to 3°.

SECT. IX.

CONVERSION
OF
SOLIDS AND FLUIDS
INTO
RIFORM OR GAZEOUS STATE.

before that in order to render solids fluid, a caloric is necessary, which combines with the e cannot be measured by the thermometer; avour to prove, that the same holds good in ersion of solids or fluids into the vaporous or

CONVERSION
OF
SOLIDS
O THE GAZEOUS STATE.

Experiment I.

antity of carbonate of ammonia, introduce it eck of which is directed under a cylinder filled nverted in a bason of the same fluid. On ap- body of the retort, the carbonate of ammonia it will expel the mercury out of the cylinder, visible gas, and would remain so, if its tem- owered.

case with benzoic acid, camphor, and various

SECT. X.

CONVERSION

OF

FLUIDS INTO THE GAZEOUS STATE.

ALL fluids may by the application of heat be converted into an aeriform elastic state.

When we consider water in a boiling state, we find that this fluid when examined by the thermometer, is not hotter after boiling several hours, than when it began to boil, though to maintain it boiling a brisk fire must necessarily be kept up. What then we may ask becomes of the wasted caloric? It is not perceptible in the water, nor is it manifested by the steam; for the steam, if not compressed, upon examination is found not to be hotter than boiling water. The caloric is therefore absorbed by the steam, and although what is so absorbed, is absolutely necessary for the conversion of water into the form of steam; it does not increase its temperature, and is therefore not appreciable by the thermometer.

This conclusion is further strengthened by the heat given out by steam on its being condensed by cold. This is particularly manifested in the condensation of this fluid in the process of distilling, where upon examining the refrigeratory, it will be found that a much greater quantity of caloric is communicated to it, than could possibly have been transmitted by the caloric which was sensibly acting before the condensation. This may be easily ascertained by observing the quantity of caloric communicated to the water in the refrigeratory of a still, by any given quantity of liquid that passes over.

1. *The boiling points of different fluids are influenced by atmospheric pressure.*

The boiling point or the conversion of fluids into gases always takes place at certain temperatures, which is different in different fluids provided the pressure of the atmosphere be the same.

EXPERIMENT I.

Put any quantity of sulphuric ether into a Florence flask, suspend a thermometer in it, and hold the flask over an Argand's lamp, the ether will immediately begin to boil and the thermometer will indicate 98°, if the ether has been highly rectified.

EXPERIMENT II.

If highly rectified ardent spirit is heated in a similar manner, the thermometer will rise to 176°, and there remain stationary.

EXPERIMENT III.

If water is substituted it will rise to 212°.

EXPERIMENT IV.

If strong nitrous acid of commerce be made use of, it will be found to boil at 248°;—sulphuric acid at 546°;—and mercury and linseed-oil at 600°, &c.

2. *The boiling point of fluids is retarded by pressure.*

Mr. Watt heated water under a strong pressure to 400°. Yet still when the pressure was removed only part of the water was converted into vapour, and the temperature of this vapour, as well as that of the remaining fluid, was no more than 212°. There was therefore 188° of caloric suddenly lost. This caloric was carried off by the steam. Now as only about $\frac{1}{5}$ of the water

was converted into steam, that steam must contain not only its own 188°, but also the 188° lost by each of the other four parts, that is to say, it must contain 188° × 5, or about 940°. Steam therefore, is water combined with at least 940° of caloric, the presence of which is not indicated by the thermometer.

3. *When pressure is removed from the surface of bodies their conversion into the gazeous state is greatly facilitated, or their boiling point is lowered.*

In proof of this the following experiments may serve:

EXPERIMENT I.

Let a small bottle be filled with highly rectified sulphuric ether, and a piece of wetted bladder be tied over its orifice around its neck. Transfer it under the receiver of an air-pump and take away the super-incumbent pressure of the air in the receiver. When the exhaustion is compleat, pierce the bladder by means of a pointed sliding wire, passing through a collar of leather which covers the upper opening of the receiver. Having done this, the ether will instantly begin to boil, and become converted into an invisible gazeous fluid.

EXPERIMENT II.

Take a small retort or Florence flask, fill it one half or less with water, and make it boil over a lamp; when kept briskly boiling for about five minutes, cork the mouth of the retort as expeditiously as possible, and remove it from the lamp.

The water on being removed from the source of heat, will keep boiling for a few minutes, and when the ebullition begins to slacken, it may be renewed by dipping the retort into cold water.

The water during boiling becomes converted into vapour, this vapour expels the air of the vessel and occupies its place; on diminishing the heat, it condenses; when the retort is stopped, a partial vacuum is formed; the pressure becomes diminished, and a less degree of heat is sufficient to cause an ebullition.

For the same reason water may be made to boil under the exhausted receiver at 94° Fahr. or even at a much lower degree: alcohol at 56°, and ether at — 20°.

On the conversion of fluids into gases is founded the following experiment:

Experiment III.

To freeze water by means of sulphuric ether.

Take a thin glass tube 4 or 5 inches long and about two or three eighths of an inch in diameter, and a two ounce bottle furnished with a capillary tube fitted to its neck. In order to make ice, pour a little water into the tube, taking care not to wet the outside, nor to leave it moist. Having done this, let a stream of sulphuric ether fall through the capillary tube upon that part of it containing the water, which by this means will be converted into ice in a few minutes, and this it will do even near a fire or in the midst of summer.

If the glass tube containing the water be exposed to the brisk thorough air, or free draught of an open window, a large quantity of water may be frozen in a shorter time; and if a thin spiral wire be introduced previous to the congelation of the water, the ice will adhere to it, and may thus be drawn out conveniently.

A person might be easily frozen to death during very warm weather, by merely pouring upon his body for some time sulphuric ether, and keeping him exposed to a thorough draught of air.

ARTIFICIAL REFRIGERATION.

The cooling or refrigeration of rooms in the summer season by sprinkling them with water becomes likewise obvious on this account.

The method of making ice artificially in the East Indies

Depends on the same principle. The ice-makers at *Benares* dig pits in large open plains, the bottom of which they strew with sugar canes or dried stems of maize or Indian corn. Upon this bed they place a number of unglazed pans, made of so porous an earth that the water penetrates through their whole substance. These pans are filled towards evening in the winter season with water that has boiled, and left in that situation till morning, when more or less ice is found in them, according to the temperature of the air; there being more formed in dry and warm weather, than in that which is cloudy, though it may be colder to the human body.

Every thing in this process is calculated to produce cold by evaporation, the beds on which the pans are placed suffer the air to have a free passage to their bottoms, and the pans constantly oozing out water to their external surface, are cooled by the evaporation of it.

In Spain, they use a kind of earthen jars, called buxaros, which are only half-baked, the earth of which is so porous, that the outside is kept moist by the water which filters through it, and though placed in the sun, the water in the jar becomes as cold as ice.*

It is a common practice in China to cool wine or other liquors by wrapping the bottle in a wet cloth, and hanging it up in the sun. The water in the cloth becomes converted into vapour, and thus cold is produced.

* Twiss's travels through Portugal and Spain.

The blacks in Senegambia have a similar method of cooling water by filling tanned leather bags with it, which they hang up in the sun; the water oozes more or less through the leather so as to keep the outward surface wet, which by its quick and continued evaporation cools the water remarkably.

The winds on the borders of the Persian Gulph are often so scorching, that travellers are suddenly suffocated unless they cover their heads with a wet cloth; if this be too wet they immediately feel an intolerable cold which would prove fatal if the moisture was not speedily dissipated by the heat.

If a cold vessel is brought into a warm room, particularly where many people are assembled, the outside of it will soon become covered with a sort of dew.

Before some changes of weather the stone pavements, the walls of a house, the balustrades of stair-cases and other solid objects feel clammy and damp.

In frosty nights, when the air abroad is colder than the air within, the dampness of this air, for the same reason, settles on the glass panes of the windows and is there frozen into curious and beautiful figures.

Thus *fogs* and *dews* take place, and in the higher regions *clouds* are formed from the condensed vapour. The still greater condensation produces *mists* and *rain*.

SECT. XI.

CAPACITY OF BODIES FOR CONTAINING HEAT.

THE property which different bodies possess, of containing at the same temperature, and in equal quantities, either of mass or bulk, unequal quantities of heat, is called their capacity for heat. The capacities of bodies for heat are therefore considered as great or small in the ratio as their temperatures are either raised or lowered by the addition, or diminished by the deprivation of equal quantities of heat.

In homogeneous bodies the quantities of caloric which they contain are in the ratio of their temperature and quantity of mass; for instance, when equal quantities of water, oil, or mercury, of unequal temperatures are mingled together the temperature of the whole will be the *arithmetical* mean between the temperatures of the two quantities that had been mixed together. It is a self-evident truth that this should be the case, for the particles of different portions of the same substance being alike, their effects must be equal. For instance.

EXPERIMENT I.

Mix a pound of water at 172° with a pound at 32°, half the excess of heat in the hot water will quit it to go over into the

colder portion; thus the hot water will be cooled 70°, and the cold will receive 70° of temperature; therefore $172 - 70$, or $32 + 70 = 102$ will give the heat of the mixture. To attain the arithmetical mean very exactly, several precautions however are necessary.*

When heterogeneous bodies of different temperatures are mixt together, the temperature produced is never the arithmetical mean of the two original temperatures.

In order to ascertain the comparative quantities of heat of different bodies, equal weights of them are mingled together; the experiments for this purpose being in general more easily executed than those by which they are compared from equal bulks.

Experiment I.

If one pound of mercury heated to 110° Fahr: be added to one pound of water of 44°, the temperature of the blended fluids will not be changed to 77°, as it would be if the surplus of heat were divided among those fluids in the proportion of their quantities. It will be found on examination to be only 47°.

Experiment II.

On the contrary; if the pound of mercury be heated to 44° and the water to 110° then on stirring them together the common temperature will be 107°.

Hence if the quicksilver loses by this distribution 63° of caloric, an equal weight of water gains only 3° from this loss of 63° of heat. And on the contrary, if the water loses 3° the mercury gains 63°.

When, instead of comparing the quantities of caloric which equal *weights* of different bodies contain, we compare the quan-

* Crawford on Animal Heat, p. 95. &c.

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however, that they are refracted by all transparent bodies which have been employed as burning glasses.

The rays of caloric are also reflected by polished surfaces, in the same manner as the rays of light.

This was long ago noticed by Lambert, Saussure, Scheele, Pictet, and lately by Dr. Herschel.

Professor Pictet placed two concave metallic mirrors opposite to each other at the distance of about twelve feet. When a hot body, an iron bullet for instance, was placed in the focus of the one, and a mercurial thermometer in that of the other, a substance radiated from the bullet: it passed with incalculable velocity through the air, it was reflected from the mirrors, it became concentrated, and it influenced the thermometer placed in the focus, according to the degree of its concentration.

An iron ball two inches in diameter, heated so that it was not luminous in the dark, raised the thermometer not less than ten and a half degrees of Reaumur's scale, in six minutes.

A lighted candle occasioned a rise in the thermometer nearly the same.

A Florence flask containing two ounces and three drachms of boiling water, raised Fahrenheit's thermometer three degrees. He blackened the bulb of his thermometer and found that it was



fore its temperature is lowered. Or as Pictet has supposed, when a number of bodies near to each other have the same temperature, there is no radiation of caloric, because in all of them it exists in a state of equal tension; but as soon as a body at an inferior temperature is introduced, the balance of tension is broken, and caloric begins to radiate from all of them till the temperature of that body is raised to an equality with theirs. In the above experiment therefore, the placing the snow or ice in the focus of the mirror causes the radiation of caloric *from* the thermometer, and hence the diminution of temperature which it suffers.

These experiments have been lately repeated by Dr. Young and Professor Davy, at the theatre of the Royal Institution. These gentlemen inflamed phosphorus by reflected caloric; and proved that the heat thus excited was very sensible to the organs of feeling.

It is therefore evident that caloric is thrown off from bodies in rays, which are invisible, or incapable of exciting vision, but which are capable of exciting heat.

These invisible rays of caloric are propagated in right lines, with extreme velocity, and are capable of the laws of reflection and refraction.

The heating agency however is different in the different coloured rays of the prismatic spectrum. According to Dr. Herschel's experiments it follows inversely the order of the refrangibility of the rays of light. The least refrangible, possessing it in the greatest degree.

Sir Henry Englefield has lately made a series of experiments on the same subject, from which we learn that a thermometer having its ball blackened, rose when placed in the *blue* ray of the prismatic spectrum in 3′ from 55° to 56°; in the *green*, in 3′ from 54° to 58°; in the *yellow*, in 3′ from 56° to 62°; in the *full red* in 2½′ from 56° to 72°; in the *confines of the red*, in

$2\frac{1}{4}'$ from 58° to 73½°; and *quite out of the visible light* in $2\frac{1}{4}'$ from 61° to 79°.

Between each of the observations, the thermometer was placed in the shade so long as to sink it below the heat to which it had risen in the preceding observation, of course its rise above that point, could only be the effect of the ray to which it was exposed. It was continued in the focus long after it had ceased to rise; therefore the heats given are the greatest effects of the several rays on the thermometer in each observation. A thermometer placed constantly in the shade near the apparatus, was found scarcely to vary during the experiments.

Sir Henry made other experiments with thermometers with naked balls, and with others, whose balls were painted white, for which we refer the reader to the interesting paper of the baronet,* from which the above experiments are transcribed.

The coloured rays emitted from the sun and combustible bodies, since they excite heat and vision, must consist of a mixture of heat-making rays, and rays of light.

And as the rays of heat and light accompany each other when emitted from luminous bodies, the velocity with which the rays of caloric move must be equal to that of light, and hence its particles must be equally minute. They differ however in this particular, that the rays of light produce the sensation of vision, and possess certain chemical properties, whilst in those of caloric the peculiar agency of heat resides.

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* Journals of the Royal Institution, No. x, p. 202.

LIGHT.

PART IX.

THE nature of light has occupied much of the attention of thinking men, and numerous opinions have been entertained concerning it. It has been sometimes considered as a distinct substance, at other times as a quality; sometimes as a cause, frequently as an effect; by some it has been considered as a compound, by others as a simple substance. Philosophers of the present day are not agreed as to the independent existence of light, or the cause by which we see.

This is not the place for discussing the respective merits of all the ingenious hypotheses, which have been advanced concerning this subject, we shall assume the doctrine of those, who admit the independent existence of light, not only because it is more generally received, but is also best calculated to explain its chemical properties.

SECT. I.

NATURE OF LIGHT.

LIGHT is that which proceeds from any body producing the sensation of vision, or perception of other bodies, by depicting an image of external objects on the retina of the eye. Hence it announces to animals the presence of the bodies which surround them, and enables them to distinguish these bodies into transparent, opaque, and coloured. These properties are so essentially connected with the presence of light, that bodies lose them in the dark, and become undistinguishable.

Light is regarded by philosophers as a substance consisting of a vast number of exceedingly small particles, which are actuall



A *medium* is a body which affords a passage for the rays of ht.

A *beam of light* is a body of parallel rays.

A *pencil of rays* is a body of diverging or converging rays.

Converging rays are rays which tend to a common point.

Diverging rays are those which come from a point, and con- ually separate as they proceed.

The rays of light are *parallel*, when the lines which they de- ibe are so.

The radiant point is the point from which diverging rays ceed.

The *focus* is the point to which the converging rays are directed.

2. SOURCES OF LIGHT.

Light is emitted from the sun, the fixed stars, and other lu- inous bodies. It is produced by percussion, during electrisa- n, combustion, and in various other chemical processes.

Why the sun and stars are constantly emitting light, is a ques- n which probably will for ever baffle human understanding; any rate it is not connected with chemistry.

The light emitted during combustion exists previously either mbined with the combustible body, or with the substance hich supports the combustion. The light liberated during che- ical action, formed a constituent part of the bodies which act each other. The light emitted during percussion and electri- ion, &c. is foreign to our subject.

SECT. II.

PHYSICAL PROPERTIES

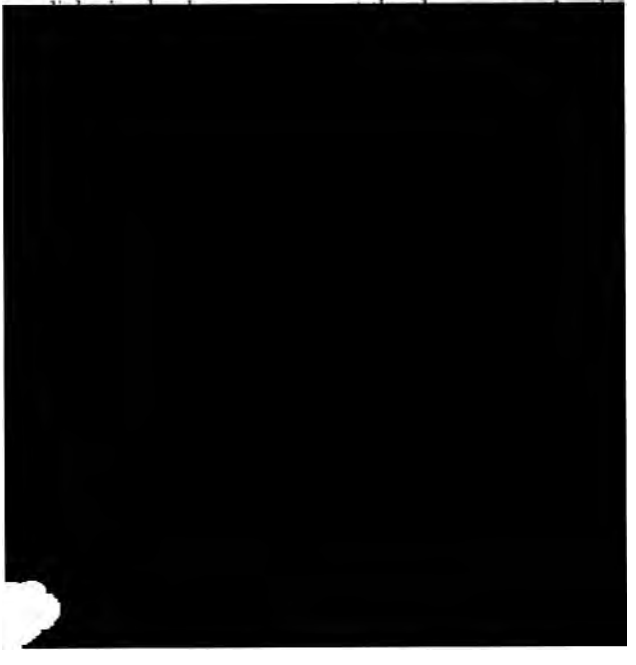
OF

LIGHT.

1. VELOCITY OF LIGHT.

THE velocity of light is much greater than that of sou
the flash of a gun fired at a considerable distance, is seen
the report is heard.

The clap of thunder is not heard till some time aft



This observation, which was first made by Roemer, has been
nfirmed by Dr. Bradley's ingenious Theory of the Aberration
the Lights of the fixed Stars.*

2. MOMENTUM AND MAGNITUDE OF THE PARTICLES OF LIGHT.

The velocity of light being thus ascertained, we should be
bled to form some notion of the magnitude of the particles of
ht, if we were in possession of good observations on the effect
their momentum.

For example; it is found that a ball from a cannon at its first
charge flies with a velocity of about a mile in eight seconds,
would therefore arrive at the sun in thirty-two years, sup-
ing it to move with unremitted celerity. Now light moves
ough that space in about eight minutes, which is two million
es faster. But the forces with which bodies move are as
ir masses multiplied by their velocities: If therefore the par-
es of light were equal in mass to the two millionth part of a
in of sand, we should be no more able to endure their im-
se, than that of sand when shot point-blank from the mouth
cannon.† How much less must therefore be the particles
light, which makes no sensible impression upon so delicate
rgan as the eye.

3. LIGHT MOVES IN STRAIGHT LINES.

Whenever light passes through a space occupied by a medium
niform density, it describes right lines in all directions.

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* Philosoph. Trans. xxxv. p. 637, and xix. p. 1.

† Nicholson's Introd. to Natural Philosophy, vol. I. p. 256.

Darken a room into which the sun shines and on
light by a small hole in the window shutter; and pl
to the hole a board or screen. If we look at the s
serve thereon, a picture of all the exterior objects wi
posite to the hole in all their natural colours: t
are faintly depicted; the images of the objects that a
as houses, trees, &c. are likewise fixed or stationa
ture; whilst the images of those that are in motion
horses, carriages, &c. are seen to move. If we p
in this ray, we find that our eye, the light and the
one and the same straight line. Which is a clear pr
is emitted in straight lines, by the luminous bodies

It is equally obvious from light finding no pas
bent or crooked tubes.

4. REFLECTION OF LIGHT.

Another property of the rays of light is their
disposition of being turned back into the medium
moved with a certain obliquity, so that the light i
without coming into contact with the matter whicl

tinues to move on till it comes to the opposite surface; but then instead of passing through, it bends and passes out again at the same surface at which it entered; just as a ball would do if made to strike obliquely against a floor.

Experiment I.

Let a beam of solar light pass into a darkened room through a hole in the window-shutter; at that part of the floor, where the beam of light falls, place a looking-glass, and then throw some hair-powder into the air in order to render the beam of light more visible.

We shall then see that the beam is reflected back into the air, and that the inclination of the reflected beam, is exactly the same as that of the incidental one.

The common experiment of children casting the light of the sun, by means of a looking-glass, into various distant places, also illustrates this property.

5. INFLECTION OF LIGHT.

When a ray of light passes within a certain distance of a body, parallel to which it is moving, it is attracted, or bent *towards* it. This inflection is caused by an attractive power to which the light is obedient.

Experiment I.

Admit a beam of light into a dark room, through a round hole in the window-shutter and place at the spot on the floor where it falls a sheet of paper, the rays of light will there form a round luminous spot. But if we bring two pen-knives, with their edges towards each other, on opposite sides of the hole, and make them approach each other gradually, the luminous spot will dilate itself on the sides of the knives, indicating that

those rays which pass nearest the edges of the knives, have been drawn from their former direction towards the knives. This property of light is called *inflection*. The edge of any other plate of metal produces the same effect.

Experiment II.

If we let a beam of light pass into a dark room through a narrow slit made in a window-shutter, not above $\frac{1}{100}$ part of an inch broad, the beam of light will be split into two, and leave a dark space in the middle, it will therefore be attracted by both sides of the slit.

Experiment III.

The shadow of a small body, as a hair, a thread, &c. placed in a beam of the sun's light, will be much broader than it ought to be if the rays of light passed by these bodies in right lines, or without being attracted by them.

6. REFRACTION OF LIGHT.

When a ray of light passes through the same medium, or when it passes perpendicularly from one medium to another, it

as their angle of incidence is more oblique. After having taken the new direction, the ray again proceeds invariably in a straight line, till it meets with a different medium, when it is again turned out of its course. This refraction of light may be illustrated by means of the following experiments:

EXPERIMENT I.

Take an empty bason, and on the bottom fix marks at a small distance from each other, then take it into a dark room and let in a ray of light; where this ray falls upon the floor place the bason, so that its marked diameter may point from the window, and so that the beam of light may fall on the mark most distant from the window. Having done this when the bason is filled with water, the beam which before fell upon the most distant mark, will now by the refractive power of the water be turned out of its straight course, and will fall two, three, or more marks nearer to the centre of the bason.

This may be more clearly proved in the following manner:

EXPERIMENT II.

Let a small bright object be laid upon the bottom of a cylindrical vessel N. B. A. L. at C. so that a ray passing in a right line from the remote edge of the object to the eye at S. will be intercepted by the edge of the vessel, or that the first ray which is not intercepted passes in the direction O. N. C. above the eye. While the eye continues in the same situation, if the vessel be filled with water the object will become visible, that is the ray which passed from the remote edge of the object in a right line C. N. O. by the vessel, on entering the air is refracted into the direction N. S. towards the eye or from the perpendicular P. N. A.



l bodies be placed in these *spectra*, they will appear of colour, red in the red light, green in the green light, &c. composition effected by means of the prism has there- called an analysis of light.

coloured rays differ from each other in reflexibility, re- y, and inflexibility. The red is the most refrangible, the least; the others are refrangible in the following nely, orange, yellow, green, blue, indigo, and violet.

erschel has lately proved* that the rays of light differ ower of illuminating objects. The rays towards the the spectrum possess the greatest illuminating powers, at the extremity, the least; the illuminating power of gradually diminishes from the middle of the spectrum extremities.

een supposed that three of these colours, the red, yel- lue, were simple; and that the other four were formed two contiguous ones; that is, the orange from the red ; the green from the yellow and blue; the indigo blue and violet; and the violet from the indigo and this supposition has not yet been satisfactorily proved.

* Philosoph. Trans. 1800. p. 255.

SECT. IV.

THEORY OF COLOURS.

HAVING so far considered the nature and effects of light, and seen that it is subject like other matters to the laws of attraction and repulsion, and that it may be analysed by means of the prism into several rays of different tints; we shall now endeavour to prove, that from the nature of these different tints, arises that variety of shades which paints the face of nature.

Hence it is that whatever pleasure we derive from the beauty of colouring, is owing to the different refrangibility of light, each object sending back to our eyes, those rays, which the peculiar structure of its surface is best adapted to reflect: In this sense, the blushing beauties of the rose, and the modest blue of the violet, may be considered as not in the object themselves, but in the light that adorns them in those robes.

The colours of all natural bodies depend on this refrangibility of light; they may be considered as prisms, which decompose or rather divide the light. Some reflect the rays without producing any change, and these are *white*; others absorb them all and are therefore *black*; the greater or less affinity of the several rays with various bodies is no doubt the cause that when a pencil of light falls upon a body, some rays enter into it, whilst others are reflected; and it is this which affords the diversity of colours and the prodigious variety of shades under which bodies appear to our eyes: and thus are formed the pellucid stream, the green sea, the white froth, the dark pool, the azure sky, the varying colours of the pigeon's neck, the opal, the mother of pearl, the

silk called changeable, &c. and hence the white colour of the European, the copper colour of the American, and black colour of the Negro.

WHITENESS.

The most curious composition of light, is that of whiteness; there is no one sort of rays which can alone exhibit this colour, it is always compound, and to its composition all the aforesaid primary colours are necessary. It is the most surprising composition, an assemblage of all the colours of the prism, in union in a due proportion. *Whiteness therefore or the solar light, is always compound*, it is produced by a copious reflection of the rays of all sorts of colours.

A spinning-top painted on the surface with the colours of the spectrum of the prism may serve to prove this. On spinning the top, it revolves rapidly on its axis; while it is so revolving, none of the colours can possibly be distinguished singly, but the whole appears *white*; this whiteness will be greater in proportion as the primitive colours are brighter.

BLACKNESS,

On the contrary, is produced by a total absorption of the incidental light, which being stopped or absorbed in the body is not reflected outwards, but refracted within, hence it is lost and produces darkness.

Such are the principal physical properties of light. Optical writers may be consulted for a great number of curious and useful deductions made from these principles and applied to the doctrine of vision, the nature of colours, the construction of mirrors, and other instruments, not immediately within the province of chemistry.

SECT. V.

CHEMICAL PROPERTIES OF LIGHT.

THE chemical effects of light have much engaged the attention of philosophers. Its influence upon animal, vegetable and mineral substances shall form the subject of the following heads.

1. EFFECTS OF LIGHT ON VEGETABLES.

Every body knows that most of the discous flowers follow the sun in his course; that they attend him to his evening retreat and meet his rising lustre in the morning with the same unerring law. It is also well known that the change of position in the leaves of plants at different periods of the day is entirely owing to the agency of light, and that plants which grow in windows in the inside of houses are as it were solicitous, to turn their leaves towards the light. Natural philosophers have long been aware of the influence of light on vegetation. It was first observed that plants growing in the shade, or darkness, are pale and without colour. The term *etiolation* has been given to this phenomenon, and the plants, in which it takes place, are said to be *etiolated* or *blanched*. Gardeners avail themselves of the knowledge of this fact, to furnish our tables with white and tender vegetables. When the plants have attained a certain height, they compress the leaves, by tying them together, and by these means (or by laying earth over them) deprive them of the contact of light: and thus it is that our white celery, lettuce, cabbages, endive, &c. are obtained. For the same reason wood is white under the the green bark; roots are less coloured than plants; some of them alter their taste, &c. they even acquire a deleterious

quality when suffered to grow exposed to light. Potatoes are of this kind. Herbs that grow beneath stones or in places utterly dark, are white, soft, aqueous and of a mild and insipid taste. The more plants are exposed to the light, the *more colour* they acquire. Though plants are capable of being nourished exceedingly well in perfect obscurity, and in that state they even grow much more rapidly than in the sun, (provided the air that surrounds them is fit for vegetation,) they are colourless, and unfit for use.

Professor Davy* found by experiment that red rose-trees carefully excluded from light, produce roses almost white. He likewise ascertained that this flower owes its colour to light entering into its composition, that pink, orange and yellow flowers imbibe a smaller proportion of light than red ones, and that white flowers contain no light.

But vegetables are not only indebted to the light for their colour: taste and odour are likewise derived from the same source.

Light contributes greatly to the maturity of fruits and seeds. This seems to be the cause why under the burning sun of Africa vegetables are in general more odoriferous, of a stronger taste, and more abounding with resin. From the same cause it happens that hot climates seem to be the native countries of perfumes, odoriferous fruits, and aromatic resins.

The action of light is so powerful on the organism of vegetables, as to cause them to pour forth torrents of pure air from the surface of their leaves into the atmosphere, while exposed to the sun; whereas on the contrary, when in the shade, they emit an air of a noxious quality.

* Beddoes's Physic. and Medic. Contrib. p. 790.

Experiment I.

Take a few handfuls of fresh gathered leaves of mint, cabbage or any other plant; place them in a bell-glass filled with fresh water, and invert it into a bason with the same fluid. If the whole be then exposed to the direct rays of the sun, small air bubbles will appear on the surface of the leaves which will gradually grow larger and at last detach themselves and become collected at the surface of the water. This is oxigen gas, formerly called vital air.

All plants do not emit this air with the same facility; there are some which yield it the moment the sun acts upon them, as the leaves of the jacobœa or ragwort, of lavender, peppermint and some other aromatic plants. The leaves afford more air when attached to the plant, than when gathered; the quantity is also greater, the fresher and sounder they are; and if full grown and collected during dry weather. Green plants afford more air than those which are of a yellowish or white colour. Green fruits afford likewise oxigen gas; but it is not so plentifully furnished by those which are ripe. Flowers in general render the air noxious. The nasturtium indicum, in the space of a few hours, gives out more air than is equal to the bulk of all its leaves.

On the contrary, if a like bell-glass, prepared in the same manner, be kept in the dark, another kind of air will be disengaged of an opposite quality. The method of collecting and examining these gases, will be shown hereafter, and the philosophy of their production will then be more fully pointed out.

There is not a substance, which in well closed glass vessels and exposed to the suns's light does not experience some alteration.

Camphor kept in glass bottles exposed to light, chrystallises or vegetates into the most beautiful symetrical figures, on that side of the glass which is exposed to the light.

Yellow wax exposed to the light loses its colour and becomes bleached. Gum guaiacum reduced to powder, becomes green on exposure to light. Vegetable colours, such as those of saffron, logwood, &c. become pale or white, &c.

2. EFFECTS OF LIGHT ON ANIMALS.

The human being is equally dependent on the influence of light.

Animals in general droop when deprived of light, they become unhealthy and even sometimes die. When a man has been long confined in a dark dungeon (though well aired,) his whole complexion becomes sallow, pustules filled with aqueous humours break out on his skin, and the person who has thus been deprived of light, becomes languid and frequently dropsical.

Worms, grubs, and caterpillars which live in the earth or in wood are of a whitish colour; moths and other insects of the night are likewise distinguishable from those which fly by day, by the want of brilliancy in their colour. The difference between those insects in northern and southern parts, is still more obvious.

The parts of fish which are exposed to light, as the back, fins, &c. are uniformly coloured, but the belly which is deprived of light is white in all of them.

Birds which inhabit the tropical countries have much brighter plumage, than those of the north. Those parts of the birds which are not exposed to the light are uniformly pale. The feathers on the belly of a bird are generally pale or white, the back which is exposed to the light is almost always coloured; the breast which is particularly exposed to light in most birds, is brighter than the belly.

Butterflies, and various other animals of equatorial countries, are brighter coloured, than those of the polar regions. Some of the northern animals are even darker in summer, and paler in winter.

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When the shadow of any figure is thrown upon the prepared surface, the part concealed by it remains white, and the other parts speedily become dark.

For copying paintings on glass, the solution should be applied on leather; and, in this case, it is more readily acted upon than when paper is used.

After the colour has been once fixed upon the leather or paper, it cannot be removed by the application of water, or water and soap, and it is in a high degree permanent.

The copy of a painting, or the profile, immediately after being taken, must be kept in an obscure place. It may indeed be examined in the shade, but, in this case, the exposure should be only for a few minutes; by the light of candles or lamps, as commonly employed, it is not sensibly affected.

No attempts that have been made to prevent the uncoloured parts of the copy or profile, from being acted upon by light have as yet been successful. They have been covered with a thin coating of fine varnish, but this has not destroyed their susceptibility of becoming coloured; and even after repeated washings, sufficient of the active part of the saline matter will still adhere to the white parts of the leather or paper, to cause them to become dark when exposed to the rays of the sun.

Besides the applications of this method of copying that have been just mentioned, there are many others. And it will be useful for making delineations of all such objects as are possessed of a texture partly opaque and partly transparent. The woody fibres of leaves, and the wings of insects, may be pretty accurately represented by means of it, and in this case, it is only necessary to cause the direct solar light to pass through them, and to receive the shadows upon prepared leather.

When the solar rays are passed through a print and thrown upon prepared paper, the unshaded parts are slowly copied; but the lights transmitted by the shaded parts, are seldom so definite as to form a distinct resemblance of them by producing different intensities of colour.

Professor Davy has found, that the images of small objects, produced by means of the solar microscope, may be copied without difficulty on prepared paper. This will probably be a useful application of the method; that it may be employed successfully however, it is necessary that the paper be placed at a small distance from the lens.

With regard to the preparation of the solution, this gentleman found the best proportions those of 1 part of nitrate to about 10 of water. In this case, the quantity of the salt applied to the leather or paper, will be sufficient to enable it to become tinged, without affecting its composition, or injuring its texture.

Count Rumford has made some valuable experiments concerning the chemical properties that have been attributed to light.* This philosopher observed, that white ribbons wetted in a diluted aqueous solution of nitro-muriate of gold, and exposed wet to the action of the sun's direct rays, soon become tinged of a beautiful crimson colour. Magnesia wetted with a solution of nitro-muriate of gold, and exposed wet to the action of the sun's rays, soon changes to a purple, and afterwards to a deep crimson colour. But if the ribbon or magnesia after being so wetted, be dried in a dark place, and then exposed in a dry state to the sun's rays, their colour will not be sensibly changed by the action of the light.

The following method of silvering ivory, which we shall transcribe from the Count's paper† is extremely beautiful and may become a valuable acquisition to the arts.

Experiment II.

Take a slip of ivory, immerse it in a diluted solution of pure nitrate of silver, and suffer it to be immersed, till the ivory has acquired a bright yellow colour; then take it out of

* Rumford's Philosoph. Papers, vol. I. 1802, p. 22.

† l. c. p. 363.

the solution, and immerse it in a tumbler of pure water, and immediately expose it in the water, to the direct rays of a bright sun. After the ivory has been thus exposed for about two or three hours to the action of the sun's light, it will appear black, but on rubbing it a little, the black surface will become changed into a metallic one, resembling a slip of fine silver.

Although this coating of revived metal, is extremely thin, yet if the ivory be well impregnated with the nitrate of silver, the solution will penetrate to a considerable depth, and as fast as the silver wears off from the surface of the ivory, the oxid below it becoming uncovered, and exposed to the light, a new coating of revived metal will be formed to replace it, and the surface of the ivory will not lose its metallic appearance.

The Count further observes, that this method of silvering ivory, which is not only expeditious, but very economical, might no doubt be employed with advantage in many cases, for ornamental purposes. The process is certainly curious and beautiful when considered merely as a philosophical experiment.

All metallic oxids, but especially those of mercury, bismuth, lead, silver and gold, become of a deeper colour, by exposure to the sun; some of them become perfectly revived, others only partially, as may be seen by observing various painter's colours, preserved in powder, and exposed to the light, in the windows of colour shops. The yellow oxid of mercury, the acetate and sweet muriate, are very soon affected by light.

The black oxid of mercury, obtained by pouring ammonia copiously into a neutral solution of sulphate of mercury, (or rather on dry sulphate) exposed to the rays of light, becomes readily converted into fluid quicksilver.

The yellow oxid of tungsten, if exposed to light, loses weight and becomes blue.

Green prussiate of iron exposed to the solar light becomes also blue.

The rose-coloured solution of sulphate of manganese becomes colourless when kept exposed to the light, and regains its colour when removed into the dark.

4. EFFECTS OF LIGHT ON ACIDS.

Experiment I.

Decomposition of nitric acid by light.

If a white glass bottle be half filled with concentrated nitric acid, and exposed to the rays of the sun, at the end of some days the white acid will be converted into an orange coloured and fuming one, and the bottle will become filled with red vapours. If the bottle be now carried into a dark place and suffered to remain there for some time, the red vapours will gradually diminish, and the acid return to its primitive or colourless state.

Nitric acid as we shall see hereafter consists of the basis of two æriform fluids, called nitrogen and oxigen. The acid in this instance loses part of its oxigen, which unites with the light and forms oxigen gas; hence the acid becomes more volatile and fuming.

d with and inverted in a bason of water, care being taken
the tube does not touch the acid; the light falling directly
the acid, decomposes it, and a part of the oxigen of the acid
omes disengaged in the gazeous form, and passes into the
iver.

Thus there remains no doubt that light acts chemically on va-
s substances. We have seen that incombustible bodies, such
xids of metals, become combustible when exposed to the
; that acids are decomposed by its contact; that various other
tances change their nature; that vegetables acquire colour,
r, taste and inflammability, whereas on the contrary deprived
ght, they remain pale and insipid, and are what is called
ted or blanched.

ght therefore enters into the composition of bodies, and its
ts are so considerable, that the skilful operator ought to be
tantly aware of the influence it may have upon the products
nitted to his investigation.

SECT. VI.

COMBINATION OF LIGHT WITH DIFFERENT BODIES.

PHILOSOPHERS have ascertained that various bodies, if e posed to light, either at a high or low temperature, comb with it and emit it again, without alteration, under certain c cumstances.

Substances of this kind have been called

SOLAR PHOSPHORI,

Or substances which shine in the dark without emitting hea after having been exposed to the light.

The world is stocked with an immense variety of bodies this kind. All terrestrial objects not only possess a power of sorbing light, but they likewise emit it again. The eyes of c owls, and several other animals, are constructed so as to coll light, to enable them to find their food in the dark. Water c densed into the form of ice or snow emits light remarka This accounts for the light afforded by show, even when heavens are involved in extreme darkness. The snow on ground absorbs light, by being exposed to it all the day, emits a considerable quantity again in the dark.

The principal bodies of this kind are the following:

1. SULPHURET OF BARYTES,

OR

BOLOGNIAN PHOSPHORUS.

The process for preparing this phosphorus is as follows: pieces of sulphate of barytes are first made red-hot, for a few minutes, in a covered crucible, placed in the middle of a fire, and then left to cool. When cold they are pulverized in a stone mortar, and sifted. This powder is formed into a paste with a little mucilage of gum arabic, and divided into cakes, cylinders, or pieces of the thickness of a quarter of an inch. Those pieces are dried in a moderate heat, and then exposed, by degrees, to a more violent heat, among charcoal, in a strong drawing wind-furnace. As soon as the coals are half consumed, the furnace must be filled a second time, and the phosphorus be left undisturbed. When the coals are quite consumed the ashes must be carefully blown off with a pair of bellows, and the phosphorus is found at the bottom of the grate.

These phosphoric stones exposed for a few minutes to the light, shine when taken into the dark like burning coals. Even immersed in water, they emit the same glowing light. Not only this phosphorus, but likewise all other phosphori of this class, lose their luminous property gradually, which they however regain on being heated a second time.

RATIONALE....During the process of preparing the Bolognian phosphorus a partial decomposition of the sulphuric acid of the sulphate of barytes takes place. The ignited charcoal, at a high temperature, has a greater affinity to the oxigen of the sulphuric acid than the sulphur has, it therefore attracts it, and forms carbonic acid gas; part of the sulphur of the sulphuric acid becomes thus separated; it unites to the pure barytes, and forms sulphuret of barytes, which seems in this union more disposed to decompose oxigen gas, than when single. The

phenomenon is therefore to be considered analogous to a slow combustion of the sulphur; the extrication of caloric, during each instant of observation, being too inconsiderable to be appreciable either by the senses or by the thermometer.

2. SULPHURET OF LIME,

OR

CANTON's PHOSPHORUS.

To prepare this phosphorus, take some oyster shells, calcine them, by keeping them in a good coal-fire, for about an hour. Then let the purest part of the lime so obtained, be pulverized and sifted. To three parts of this powder, add one of flowers of sulphur, mix them well together, put the whole into a crucible, and ram it tightly. Let it then be placed in the middle of a fire, where it must be kept red hot for an hour at least, it may then be removed to cool. When it is cold cut or break the mass to pieces. Scrape off the brightest part, which if good, will shine in the dark. This is to be kept in a glass phial, hermetically sealed.

This is Canton's phosphorus. The quantity of light which a little of it gives, when brought into a dark room, after it has been exposed for a few minutes to the sun, or even day-light is sufficient to shew the hour by a watch, if the eyes have been previously kept shut a minute or two.

RATIONALE...Analogous to the former.

3. NITRATE OF LIME,

OR

BALDWIN's PHOSPHORUS

Is a combination of nitric acid, with lime, obtained by dissolving carbonate of lime in nitric acid; and evaporating the solution in an earthen vessel to dryness. This solid salt

is then to be rammed into a crucible, which is placed in the middle of a good fire, where it is to be kept, till the whole mass becomes liquid. As soon as the mass has fused about eight minutes, the crucible is to be removed, and its contents poured out into an iron pot, previously heated. This mass when still hot, is to be preserved from the contact of the air in a well stopped phial.

Baldwin's phosphorus when well prepared, shines with a beautiful white light, after having been exposed to the sun for a few hours.

Modern observations have made us acquainted with several other bodies which possess the property of shining, after having been exposed to an elevated temperature. We know that, not only all neutral salts with a base of barytes belong to this class; but also many other substances, namely, diamonds, and several precious gems, magnesia, carbonate of magnesia, sulphate and carbonate of lime, aluminous earth, sulphate of potash, sulphate of strontian, some metallic oxids, cotton wool, appatite, zeolite, &c. display the same phenomena.

The combination of fluoric acid with lime, commonly called fluor spar or fluate of lime, is remarkable on account of its property of shining in the dark, at an elevated temperature only. When the phosphoric flour spar is reduced to a fine powder, and placed in contact with any body, heated to about 212° Fahr. though not ignited, and afterwards taken into a dark place, it shines with a phosphoric light. By this means may be performed writings, drawings, &c. upon an iron or copper plate, with a thin mucilage of gum arabic or with white of egg and strewing over it some fine powdered fluate of lime. When this is dry, all the superfluous powder must be carefully blown off and the plate removed over a gentle coal fire. As soon as it is heated the delineated objects become luminous, and opake again when the plate becomes cold.

Not only a great variety of mountain crystals, lapis lazuli, several kinds of stones, &c. become luminous in a high temperature, but also Dr. Marum observed, that a phosphoric light is discernable in expressed oils and animal fats, when heated to 450° Fahr.

PHOSPHORIC SUBSTANCES WHICH BECOME LUMINOUS BY ATTRITION OR PERCUSSION.

The most celebrated and most anciently known body of this kind is called

MURIATE OF LIME,
OR
HOMBERG's PHOSPHORUS.

Homberg's process for obtaining this phosphorus, is as follows: One part of powdered muriate of ammonia is mixed with two of powdered lime, introduced into a red hot crucible, and keep hot till the mixture becomes liquid. As soon as the mass has been fused for a few minutes it is poured out, into a heated iron pot, broken into pieces, and preserved in a well stopped phial.

This substance has the property of emitting a phosphoric light, when struck or excited with a hard sharp body in the dark. When a red hot poker is dipped into the fused substance, and rubbed after it is cool with another piece of metal, it becomes luminous, and gives out phosphoric sparks and light.

This phosphorus is obtained more conveniently as well as at less expence, when that portion of muriate of lime, which remains in the retort, after the decomposition of muriate ammonia by lime is melted and then exposed for some minutes to such a degree of heat, as is sufficient to melt the surface of a

green glass matrass; it acquires the property of giving fire with steel, and emits phosphoric sparks and flashes of light in a high degree.

Those kind of phosphori or substances which give a perceptible sparkling light by attrition or percussion, without having been exposed either to the solar light or fire, are likewise numerous. Flints, and several other siliceous stones, struck against one another, appear luminous in the dark, some through the whole mass, others only on the side struck upon. Tremolit, phosphate of lime, black-jack, and other stones of this genus, become luminous or yield phosphoric light in the dark, when struck with a sharp instrument. Gum elemi, various resins, and sugar, emit a perceptible light by attrition or percussion, without having been exposed to light or heat.

Mr. T. Wedgwood* has published an excellent paper on the light produced by attrition.

Mr. Coates† of Clifton observed, that if two pieces of bonnet-cane were rubbed together in the dark, light was liberated. Professor Davy who pursued this experiment found that all canes of this kind when briskly rubbed together produce sparks or white light, which are more vivid on collision.

But the most perfect phosphorus of this class, is supersaturated borate of soda. Two pieces of this salt struck one against another, or a swift blow with any sharp instrument upon it, produces such a flash of white light, as none of the before-mentioned substances are capable of giving.

Other substances again emit light on immersion into acids.

Mr. Westrumb‡ observed that when fresh decarbonated magnesia, is thrown into concentrated sulphuric, acid light is liberated which produces an appearance similar to that known by the name of red heat.

* Philosoph. Trans. 1792. † Nicholson's Journal, May, 1799, p. 56.
‡ Crell's Chemic. Annals, 1784, p. 432.

Experiment I.

To perform this experiment about two scruples or one drachm of magnesia recently freed from carbonic acid by heat must be put into a tea-cup, and half an ounce of highly concentrated sulphuric acid poured over it at once, so as to cover the magnesia. A prodigious quantity of vapour is instantly extricated, sparks are thrown about, and the mixture becomes ignited. Mr. Westrumb observed, that coloured (or partly deoxigenated) sulphuric acid answered the purpose better, than when the acid was colourless.

During the combination of lime with muriatic acid, and of dry caustic potash or soda with sulphuric acid, a white light is uniformly perceived.

Various animal and vegetable substances, likewise emit light under peculiar conditions only. Fish, and several other marine animals, both in a living state, and when dead, possess this property; as instances of the first may be mentioned the shell-fish called *pholas*, the *medusa* phosphorea, and various other *molluscæ*.

In the class of insects are many which emit light very copiously, particulary several species of *fulgora* or lantern fly, and of *lampyris* or glow-worm; also the *scolopendra electrica*, and a species of crab, called *cancer fulgens*.

Rotten wood is well known to emit light spontaneously. Peat earth has also the same property.

The flesh of quadrupeds has also been observed to emit light.

The softest parts become often totally phosphoric, it appears in this state, as if sprinkled over with gems. Upon touching the brilliant luminous particles they come off, and appear almost liquid.

The medullary substance of the brain of human beings or rather the nervous system in general is said to possess this property in a high degree; it is this particularly which gives rise to those phosphorescent lights frequently observed in anatomical theatres

Citizen Cabarris, who read a memoir on this subject before the national institute, remarks that a variety of observations have made him conclude, that the quantity of phosphorescent matter after death, bears some proportion to the activity of the nervous system during life.

Dr. Hulme has made some interesting experiments on the light which is spontaneously emitted from various bodies. He believes (as is highly probable) that the light is a constituent part of many animals, particularly of the marine fishes, that it may be separated, collected, and rendered permanent for some time by peculiar processes, for which we refer our reader to the interesting, curious, and well conducted experiments enumerated in paper.*

PHOTOMETER.

In order to measure the relative intensity of light emitted by luminous bodies, various kinds of contrivances called PHOTOMETERS have been contrived. The most perfect instrument of that kind, is the photometer invented by Count Rumford. By means of this instrument, the Count has made a series of interesting experiments, in order to determine the quantities of light produced by lamps and candles of different kinds, and the relative expense of lighting rooms in various ways. The Count found that the saving in the quantity of oil consumed, by an Argand's lamp, compared with one of the common construction with a ribbon wick, amounted to about 15 *per cent.* in the production of an equal quantity of light. He also ascertained, that an Argand's lamp of the common size well trimmed, and burning with its greatest brilliancy, emitted about as much light as 10 common wax candles, each $\frac{3}{4}$ of an inch in diameter; and that the light

* Philosoph. Trans. 1800, p. 161.

Count Rumford's photometer is founded, together with masterly drawings of the instrument, which performs with utmost facility not only all the ingenious experiments of guer, Lambert, and Leslie, but many others, equally s tory, may be found in Count Rumford's work* from these *data* have been copied.

Thus far we have examined the two imponderable sub diffused through space, namely caloric and light. They hav considered by different philosophers as substances whose cles mutually repel each other, for they are never found ing together.

They agree in many of their properties; they radiat hot or luminous bodies with inconceivable velocity; th transmitted, reflected, and refracted by different subst while they have the property of combining with others.

CALORIC we have seen is the cause of the sensation o it produces expansion, is the cause of fluidity, &c.

LIGHT on the other hand, produces the sensation of and is the cause of colours. Both substances do not aff ponderability of bodies, all attempts to weigh them have h been in vain; they have therefore been called IMPONDE SUBSTANCES, if they are absolutely *imponderous* is left

SUBSTANCES NOT YET PRODUCIBLE BY ART, BUT ANALOGICALLY CONSIDERED AS SIMPLE.

PART X.

SECT. I.

OXIGEN.

THIS substance although existing sometimes in a solid, and sometimes in an aeriform state, is never distinctly perceptible to the human senses, but in combination.

We know it only in its combination, by its effects. Nature never presents it solitary; chemists do not know how to insulate it. It is a principle which was long unknown. It is absorbable by combustible bodies, and converts them into acids. It is an indispensible condition of combustion, uniting itself always to bodies which burn, augmenting their weight, and changing their properties. It may be disengaged in the state of oxigen gas, from burnt bodies, by a joint accumulation of caloric and light. It is highly necessary for the respiration of animals. It exists universally dispersed through nature and is a constituent part of atmospheric air, of water, of acids, and of all bodies of the animal and vegetable kingdoms.

One of the most remarkable combinations into which it is capable of entering, is that which it forms with light and caloric. The nature of that mysterious union has not been ascertained, but it is certain that in that state it constitutes the gazeous fluid called OXIGEN GAS, which it will be more proper to consider hereafter.

SECT. II.

HIDROGEN.

HIDROGEN is a substance not perceptible to our sensation in a separate state; but its existence is not at all the less certain. Though we cannot exhibit it experimentally uncombined, we can pursue it, while it passes out of one combination into another; we cannot indeed arrest it on its passage; but we never fail to discover it, at least if we use the proper chemical means, when it presents itself to our notice in a new compound.

Hidrogen, as its name expresses, is one of the constituent elements of water. Its existence was unknown till lately. It is plentifully distributed in nature, and acts a very considerable part in the processes of the animal and vegetable economy. It is one of the ingredients in the mixtures of bitumen, of oils, fats, ardent spirit, ether, and in fact of all the proximate component parts of all animal and vegetable bodies. It forms a constituent part of all animal and vegetable acids. It is one of the bases of ammonia and of various other compound gases.

It possesses so great an affinity with caloric, that it can only exist in the state of gas, it is consequently impossible to procure it in the concrete or liquid state, independent of combination.

Solid hidrogen, therefore, united to caloric and light forms HIDROGEN GAS, which will be noticed in its proper place.

SECT. III.

NITROGEN.

ROGEN or Azote is another simple body very abundant
re though not producible alone or in an insulated state....
ot distinctly perceptible to the human senses, however
y instruments. We know it only in its combination.
reality of its existence is unquestionable; since we can
s passage out of one combination into another; since we
he laws of chemical attraction to which it is subject; since
ern the precise character of those simple substances with
t is combinable, and can distinguish the nature of the
mpounds which the combination produces. The separate
ce and peculiar nature of this substance were first disco-
y Dr. Rutherford. It is the radical principle of our at-
ric air, and other gazeous substances, and forms a consti-
rt of animal and vegetable substances. It is a component
the nitric acid, and of ammonia. It probably enters into
nation of alcalies, and it may be considered as a real alca-
alcalizing principle, in opposition to oxigen, which, as
e noticed before is the principle of acidity. One of the
markable combinations into which nitrogen is known to
is that which takes place between it and light and caloric.
mpound thus produced is called NITROGEN GAS, which
treated of in a farther part of this work.

have noticed these three substances here separate-
ause they act so very important a part in all the pheno-
chemistry, that it is requisite to have some previous
of them before we proceed any farther. They shall be more
tantially described hereafter, together with the rest of the
numerated before in the table of simple substances.

COMBUSTIBLE BODIES, DESTITUTE OF METALLIC PROPERTIES.

SULPHUR.

PART XI.

SECT. I.

NATURAL HISTORY OF SULPHUR.

SULPHUR which is also known by the name of brimstone, the only simple combustible substance which nature offers pu and in abundance. It was the first known of all. It is found the earth, and exists externally in depositions, in sublimed crustations, and on the surface of certain waters, principally n burning volcanos. It is found combined with many metals. exists in vegetable substances, and has lately been discovered Mr. Carlisle in the albumen of eggs.*

Sulphur in the mineral kingdom is either in a loose powder compact; and then either detached or in veins. It is found the greatest plenty in the neighbourhood of volcanos or pse volcanos, whether modern or extinct as at *Solfatara*, &c. is deposited as a crust on stones contiguous to them, ei crystallized or amorphous. It is frequently met with in mi

* Nicholson's Journal, August, 1801, p. 178.

s, and in caverns adjacent to volcanos; sometimes also in nines. It is found in combination with most of the metals. n united to iron it forms the mineral, called *martial pyrites, phur pyrites*. All the ores known by the name of *pyrites* hich there are a vast variety, are combinations of sulphur different metals; and hence the names of copper, tin, ical, &c. pyrites. It exists likewise in combination with ne and lime; it then constitutes different kinds of schistus, m ores.

PHYSICAL PROPERTIES OF SULPHUR.

phur is a combustible, dry, and exceedingly brittle body, pale lemon-yellow colour. Its specific gravity is 1.990. destitute of odour, except when rubbed or heated. It is peculiar faint taste. It frequently crystallizes in entire ncated octahedra, or in needles. If a piece of sulphur of siderable size, be very gently heated; as for example, by ng it in the hand and squeezing it firmly; it breaks to pieces a crackling noise. It is a non-conductor of electricity, and it becomes electric by friction. When heated, it first sof- before it melts, and its fusion commences at 184° Fahr.; at it becomes volatilized, and takes fire at 302°. In the be- ng of fusion it is very fluid, but by continuing the heat it s tough, and its colour changes to a reddish brown. If in ondition it be poured into water, it remains as soft as wax, ields to any impression. In time however it hardens again ecovers its former consistence.

nites with most of the earths and with all alcalies, and be- s soluble, when thus combined, in water. It unites to most metals and renders them brittle and fusible. It is soluble ; water takes up a minute quantity, as does ardent spirit eans of heat. It dissolves in hidrogen gas. It does not ine with charcoal, but unites to phosphorus by fusion.

cording to the slow or rapid combustion, it a
quantities of oxigen, and the produced acid diffe
ties. Sulphur heated in a close vessel, sublimes
tion. It is not changed by exposure to air. It
the nitric acid when poured on it in its fused stat

METHOD OF OBTAINING SULPH

A prodigious quantity of sulphur is obtained
in Italy. This volcanic country every where exhit
agency of subterraneous fires; almost all the
and white; and is every where sensibly warmer
phere, in the greatest heat of summer; so that
sons walking there are burnt through their shoes.
ble not to observe the sulphur, for a sulphureou
rises through different apertures is every where
gives reason to believe that there is a subterran
neath from which that vapour proceeds.

From pyrites sulphur is extracted in the large
lowing process:

Pyrites is broken into small pieces, and put in
tubes which are exposed to the heat of a furn
vessel of cast-iron, containing water, is connecte
with the tube in the furnace. The action of th

to free it from the rest of the impurities. It is then tolerably pure, and constitutes the sulphur we meet with in large masses or lumps in the market.

In order to form it into rolls, it is again melted and poured into cylindrical wooden moulds, in these it takes the form in which we usually see it in commerce, as roll sulphur.

Flowers of sulphur as they are called, are formed by subliming purified sulphur with a gentle heat in close rooms, where the sublimed sulphur is collected, though the article met with in general under that name is nothing but sulphur finely powdered.

METHOD OF PURIFYING SULPHUR.

Take one part of flowers of sulphur, boil it in twenty parts of distilled water in a glass vessel for about a quarter of an hour; let the sulphur subside, decant the water, and then wash the sulphur repeatedly in distilled water: having done this, pour over it three parts of pure nitro-muriatic acid, diluted with one part of distilled water, boil it again in a glass vessel for about a quarter of an hour, decant the acid, and wash the sulphur in distilled water till the fluid passes tasteless, or till it does not change the blue colour of tincture of cabbage, or litmus. The sulphur thus carefully treated is PURE SULPHUR fit for philosophical experiments.

We shall now endeavour to prove some of the before stated properties of sulphur.

SECT. II.

EXPERIMENTAL PROOFS OF THE PROPERTIES OF SULPHUR.

EXPERIMENT I.

Slow combustion of sulphur.

PUT some threads previously dipped in sulphur into a cup other vessel floating on water. Set fire to the threads and cov the whole with an inverted glass receiver. The threads will con tinue to burn for some time, and the whole receiver will becom filled with a dense white vapour. The water will ascend into th receiver. The whole is then to be left till the vessel is becom

Experiment II.

Rapid combustion of sulphur.

Take a large receiver or any other round bellied bottle with a wide orifice, containing a little water, fit a bung to close it, and fasten to this bung an iron or rather earthen-ware spoon, containing a mixture of one part of nitrate of potash and six of sulphur blended together. Set fire to the mixture and introduce it expeditiously into the vessel, taking care to close the mouth accurately. In this case, the combustion will go on very rapidly, and the water at the bottom of the vessel will become sour, but without possessing much suffocating odour.

Rationale...In this experiment the combustion is not slow, but on the contrary very rapid; for the nitric acid of the nitrate of potash is decomposed, and furnishes oxigen gas, into which the sulphur is plunged the instant of its inflammation. It therefore absorbs a much greater quantity of oxigen and furnishes *sulphuric acid*, different in properties from the former, which is not completely oxigenated, and therefore is pungent and volatile.

Experiment III.

Sulphur is soluble in ardent spirit only in a state of extreme comminution.

If a piece of sulphur be left in contact with ardent spirit for any length of time, the spirit will not act upon it; but if we present the sulphur in its smallest division to the spirit, an union will then take place.

To perform this experiment, put pounded sulphur into a matrass furnished with an alembic; suspend within it a cup or

wide-mouthed bottle containing strong ardent spirit, then put on the alembic and adjust a phial to the beak; lute well the joinings, and heat the lamp.

The sulphur and spirit will now meet in a state of vapour, and the fluid which distils over, will contain sulphur in solution.

To prove that sulphur is dissolved in the spirit, water may be added; the spirit will unite to the water, and the sulphur be precipitated.

This furnishes an instance that chemical attraction takes place only between the minutest parts of bodies. (See page 46.)

Experiment IV.

Action of caloric on sulphur.

If sulphur be put in a crucible placed among burning coals, it will soon enter into fusion. This first fusion is liquid, but if it be kept longer over the fire it becomes tenacious and very thick. When poured into water in this state, it will be as soft as wax, and may be easily worked into any form between the fingers, instead of being solid or brittle as sulphur is in common. Sulphur in this state may be employed with advantage as a paste for taking impressions from seals and engraved stones.

It is this property of sulphur of which Mr. Tassie has availed himself to furnish elegant impressions of antique gems.

If melted sulphur be withdrawn from the fire as soon as it is completely melted, and left to cool slowly, its parts assume a regular symmetrical arrangement, disposed in needles, which form a crystallization of sulphur.

If the vessel in which the sulphur is kept melting, be covered with another vessel, and the air be excluded by luting, flowers of sulphur will be obtained in the upper vessel.

COMBINATION OF SULPHUR WITH METALS.

Sulphur and iron have a great attraction to each other; the iron becomes of easy fusion and brittle by this union.

Experiment I.

Formation of sulphuret of iron.

If a bar of iron be heated to *perfect whiteness* and then touched with a roll of sulphur, the two bodies combine and drop down together in a fluid state, forming sulphuret of iron, a compound of the same nature as the native iron pyrites.

By this method a bit of iron rolled out very thin may be *apparently* melted in the hand, by putting it when heated to whiteness, upon a thick piece of solid sulphur.

Remark...It is necessary that this experiment be performed under a chimney, or in a place where there is a current of air, to carry off the suffocating vapours.

Experiment II.

Artificial Volcano.

The following experiment affords a beautiful and curious representation in miniature of one of the grandest and most terrible phenomena in nature. For the introduction of it to modern notice, we are indebted to the accident of a man having collected some tons of a native mixture of iron and sulphur (iron pyrites) beneath an old shed; where, not sufficiently protected from rain and the moisture of the atmosphere, it soon swelled, became hot, cracked, emitted sulphureous vapours, ignited and lastly burnt with considerable violence.

sulphur into small glass phials, from which common air was cluded, being in some cases filled with carbonic acid gas, a trogen gas, and in others, with water or mercury.

Whenever the phial was heated under any of these cir stances, the mixture began to swell; the metal always be *red hot* and in some cases real inflammation took place, notw standing the exclusion of oxigen gas.

The proportions that produced most ignition or flame, we parts of copper and 15 of sulphur.

Iron and sulphur inflamed like copper. The best propo was three parts of iron and one of sulphur.

Tin and sulphur succeeded in the same proportion.

Lead and sulphur, the proportions being as 45 of the fo and 15 of the latter.

Zinc and sulphur in the same proportion burned with plosion.

Mercury, bismuth, antimony, and cobalt, could not be t to inflame with sulphur.

These experiments succeed equally well in the Torrice vacuum.

COMBINATION OF SULPHUR WITH ALCALIES

water is decomposed by the joint action of the ingredients, the oxigen from the water (its caloric at the same time set free) forms with the sulphur a considerable portion of uric acid which by the further assistance of water, furnish- xigen, attacks the iron. Here then are two sources of c and hidrogen gas (the other principle of water) which in scent state seizes on a portion of sulphur, and forms another nd inflammable compound called sulphurated hidrogen gas; decompositions taking place through the whole mass occa- the heat, swelling, bursting, and discharge of clouds of ureous vapour. While these effects are rapidly going on, mperature increases sufficiently to kindle a particle of sul- which communicating with the inflammable gases produces plosion, occasionally repeated as fresh quantities of gas are ed, the whole being now in a state of combustion burns as ıs the sulphur or any other inflammable matter remains. ere is no doubt that the combustion of those enormous s of bituminous pyrites, which are deposited in the bowels e earth produce volcanos on the same principles. The de- osition and action of the constituent principles of the water the component parts of the pyrites fully determine all the omena.

Experiment III.

Accension of sulphur and metals.

e union of sulphur with copper and other metals at a low erature is attended with some remarkable phenomena. In to exhibit this experiment mix three parts of copper filings, ne of sulphur reduced to powder, intimately together; in- ce this mixture into a glass tube or Florence flask, and it gradually over a lamp or coal fire. After the mixture has heated to a certain degree, it begins to swell, and a small ed spark becomes first visible at the bottom of the glass ves-

[illegible]

[illegible]

[illegible]

PHOSPHORUS.

PART XII.

SECT. I.

NATURAL HISTORY OF PHOSPHORUS.

PHOSPHORUS is the next simple body we have to consider; has never been found pure in nature. It is always met with ited to oxigen, or in the state of phosphoric acid. In that te it exists very plentifully, and is united to different animal, getable, and mineral substances.

PHYSICAL PROPERTIES OF PHOSPHORUS.

Phosphorus is a flesh-coloured or yellowish semi-transparent stance, of the consistence of wax, but brittle during frost. In nospheric air it is luminous at common temperatures without itting heat. It has a rough disagreeable taste, and its odour embles that of garlic. Its specific gravity is 2.033, water ng 1.000. Phosphorus crystallizes in laminæ, in needles, or ngated octahedra. Exposed to the light it becomes covered h a crust which is first white, next orange and at last red.

...xygen from this acid, and ea...
...phosphorus passes over.

M...METHOD OF PURIFYING PHOSPH...

...phorus in a different manner is of a ...
...a certain quantity of cha...
...gives it that appearanc...
...cut into a piece of ch...
...The whole is then immer...
...phosphorus melts and ma...
...care to keep it under the ...
...supply phosphorus by a ...

...means of hidrogen gas.

METHODS OF MOULDING PHOSPHORUS INTO CYLINDERS.

...phorus into sticks, a funnel w...
...the lower orifice of which is clo...
...to be filled with water and p...
...stung into boiling water, the ...

d soda of the urine, hence phosphate of lead and ni-
da and ammonia are formed. The former being in-
lls to the bottom, and the latter salt remains in the
nt fluid. On adding charcoal to the phosphate of
exposing it to a high temperature, the union is again
the phosphoric acid becomes decomposed, its oxigen
the charcoal and forms carbonic acid gas, which flies
the distillation; the phosphorus appears in its simple
the metal is left behind in the retort together with
abundant quantity of charcoal.

2. NICOLA's PROCESS.

quantity of bones of adult animals, burn them to white-
open fire and reduce them to a fine powder. Upon
nds of this powder, after having been put into a
here may be poured two pounds of concentrated sul-
d of commerce; four or five pounds of water must
rds added by degrees, to assist the action of the acid.
e whole process, the operator must place himself and
so that the fumes of the mixture may be blown from
whole is then to be left in a gently heated sand-bath
welve hours or more, taking care to supply the loss of
ch happens by evaporation. The next day a large quan-
er must be added, the clear liquor afterwards decanted
st strained through a cloth or sieve. The residuary
o be edulcorated by repeated affusions of hot-water till
steless. The water which has been used to wash out
g acid is mixed with the before decanted or strained
d the whole fluid is gradually evaporated in a flat
son to the consistence of syrup. It is then to be
an equal weight of charcoal powder and submitted
on in an iron or earthen retort. Instead of applying
the neck of the retort may be immersed in a bason of

PROPERTIES OF PHOSPHORUS

EXPERIMENT I.

Phosphorus burns at the common temperature of the a

LUMINOUS CHARACTERS.

THAT phosphorus burns at the usual temperature by writing with a cylinder of it upon black paper, or other smooth surface. The writing will appear lumin dark, as if on fire: the fiery appearance vanishes b on the object, but becomes visible again in a few seco

If the writing is performed upon the purple colour this country, the traces will appear red in the dry-lig luminous appearance has ceased.

RATIONALE...The phosphorus has been converted phoric acid, which changes the blue vegetable colour to red, the light evinces the combustion of the ph

Experiment II.

Accension of phosphorus by friction.

Fold up in a piece of brown paper a few grains of phosphorus and rub it against any hard body, or between the paper itself, the phosphorus will inflame and set the paper on fire.

A few grains of phosphorus rubbed in a mortar with iron filings, take fire instantly.

Rationale...The friction applied in these experiments raises the temperature of the phosphorus, it then attracts the oxigen from the atmosphere rapidly, in order to become converted into phosphoric acid and the heat and light both of the phosphorus and oxigen gas are set free.

Remark...It is curious that written paper inflames more readily than paper which has not been written upon. Straw and wood are extremely difficult to be fired by burning phosphorus, they become only converted into charcoal; but sulphur, cotton, ardent spirit, ether, and essential oils, take fire by it readily.

Experiment III.

A phosphoric fire bottle.

Take a small thin phial, heat it gradually in a ladle full of sand, and introduce into it a few grains of phosphorus; the phial is then to be loosely stopped and left undisturbed for a few minutes: small quantities of phosphorus are thus repeatedly added until the phial is full. Another method of preparing this phosphoric bottle consists in heating a quantity of phosphorus and lime mixt together in a loosely stopped phial for about half an hour.

To use this fire-bottle, a common match or small bit of wood tipped with sulphur, is introduced into the phial, turned

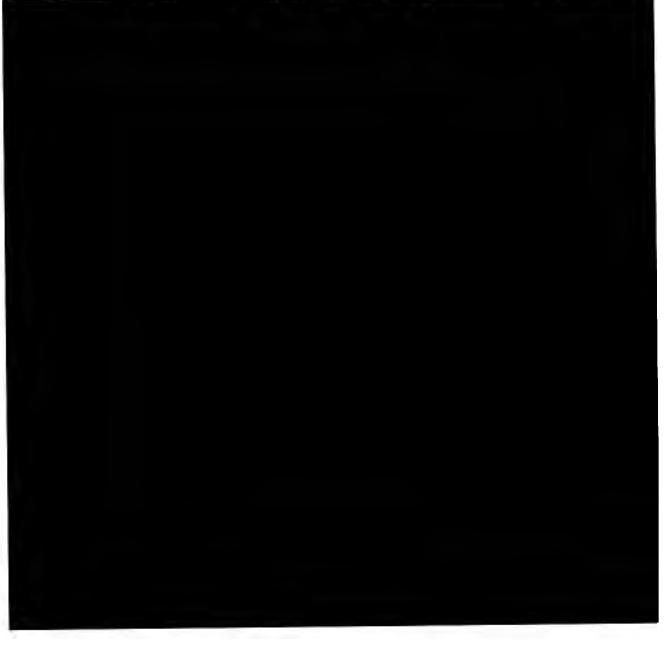
round, and quickly drawn out, which causes the phosphor take fire as soon as it comes out of the bottle.

Phosphoric fire bottles may also be prepared by uniting part of sulphur with eight of phosphorus; this compound inflammable that if a minute quantity be taken out of the b with a match, and rubbed upon a cork, it inflames instantly, fires the match.

Experiment IV.

Phosphoric tapers.

Take a glass tube, about four inches long and one line closed at one end. A small quantity of phosphorus is to be troduced into the tube and pushed to its extremity with an wire, after which a taper covered at one end with wax is into it; the open end of the tube is then hermetically and the other, plunged into hot water. The phosphorus and fixes as it cools upon the taper. A line is then drawn means of a diamond or file at one third of the tube. To use tapers, the tube is broken at the marked line and when it



omes again phosphorescent, and this may be renewed whole of the ether has been decomposed.

pen be dipped in water, and in this state be plunged phorated ether, at the moment of contact of the two udden light spreads through the air, and very percep- es are seen (in a dark place) to issue from time to time mouth of the phial.

en a lump of fine loaf sugar is wetted with phospho- er, and thrown into a bason of water, the whole of e will be illuminated; by gently blowing it, beautiful ns will be formed greatly resembling the fiery appear- e sea.

se experiments with phosphorated ether succeed best er be a little warm.

NALE...The phosphorated ether is decomposed on com- ntact with a large quantity of water; the water unites ether; the phosphorus being then presented to the air d exhibits the luminous appearance.

norated ether is best prepared by suffering sulphuric tand for some weeks over a considerable quantity of us in a well stopped phial.

Experiment VI.

Liquid phosphorus.

phosphorus is dissolved in oils it forms what is called osphorus. The best method of preparing it, is to boil tly one part of phosphorus with six of oil of olives. hus charged with phosphorus must be kept in a bottle- ed. It has the property of becoming luminous in the oon as the phial containing it is unstopped, and opaque hen the phial is corked. This liquid may serve for

Experiment VII.

Accension of phosphorus by means of sulphuric acid and

Melt over a slow fire, in a cup, gallipot, or phial, co
a table spoonful of water, a small quantity of phosph
soon as the water boils, pour into it double the quan
measure, of concentrated sulphuric acid. In a few min
surface of the mixture becomes filled with luminous va
considerable ebullition takes place, accompanied with a
noise, which increases gradually, until the mixture ta
with a smart explosion; little fire-balls and stars will be
out in all directions and the whole will boil very high.

Rationale...This accension of phosphorus is owing
heat evolved by the mixture of the acid and water.

Remark...To perform this dangerous experiment with
the vessel containing the water and melted phosphorus sh
fastened to the end of a long stick, in order that the
may be at a sufficient distance when the explosion take
as it frequently happens that the vessels are dashed to pi
moment the mixture is made, and the whole is throw

Experiment VIII.

A phosphoric fire-work.

Put a piece of phosphorus about the size of a large bean, into a clean Florence flask, holding it slanting that it may not break the glass, and pour upon it about six ounces of water, place the whole over a lamp and light the wick, which should be about half an inch from the flask; as soon as the water is heated, streams of fire will issue from it by starts, resembling sky-rockets, some particles will adhere to the sides of the flask and represent stars, and will frequently display brilliant rays. These appearances will continue at times till the water begins to simmer, when immediately a curious *Aurora Borealis* begins, and gradually ascends, till it collects into a pointed flame: when this has continued about half a minute blow out the flame of the lamp, and the apex of the flame will rush down, forming beautiful illuminated clouds of fire, rolling over each other for some time, which disappearing, a splendid hemisphere of stars presents itself: after waiting a minute or two, light the lamp again, and nearly the same phenomena will be displayed as from the beginning. Let a repetition of lighting and blowing out the lamp be made three or four times at least, that the stars may be increased. After the third or fourth time of blowing out the lamp, and in a few minutes after the internal surface of the flask is dry, many of the stars will shoot with great splendor from side to side, and some of them with brilliant rays; and these appearances will continue several minutes.

Rationale...Part of the phosphorus in this experiment, detaches itself from the water, and becomes dissolved in the vapour of that fluid, which on coming in contact with the atmospheric air takes fire, and accounts for the phenomena.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

ing water; then fill the tube with small bits of fresh lime of the size of split peas; stop the opening of the oosely with a chalk stopper, to prevent the access of air; heat to redness *that part of the tube which contains the* by means of charcoal; when the lime may be supposed to ited, apply heat to the part containing the phosphorus, so ublime it, and to bring the vapour of it into contact with ated lime. The lime and phosphorus will unite and form ture of a reddish-brown colour, which is phosphoret of This preparation has the property of making fire rise out ter, when a small bit is dropt into it.

TIONALE....The phenomena is owing to a decomposition ter, at the common temperature, which shall be more fully d on under the article, *phosphorated hidrogen gas.*

MARK....If a glass tube be made use of for preparing phos- t of lime, that part of the tube which is heated (which may niently be done by passing it through a perforated crucible afing-dish, filled with ignited charcoal) should be coated clay, or loam, in order to secure it from breaking during ocess.

DIAMOND,

OR

PURE CARBON.

PART XIII.

SECT. I.

NATURAL HISTORY OF DIAMOND.

THE diamond, which was well known to the ancients, is p
cipally found in the western peninsula of India, on the coa
Coromandel, in the kingdoms of Golconda and Visapour, i
island of Borneo, and in the Brazils.

They are generally found bedded in yellow ochre, c
rocks of free-stone, or quartz, and sometimes in the bec
running waters. When taken out of the earth they are incr
with an exterior earthy covering, under which is another,
sisting of carbonate of lime.

In the Brazils, it is supposed that diamonds might be obt
in greater quantities than at present, if the sufficient worki
the diamond mines was not prohibited, in order to prevent
diminution of their commercial value, which a greater abund
of them might occasion.

REMARK...Brazilian diamonds, are in commercial estim
inferior to the oriental ones.

In the rough, diamonds are worth two pounds sterling the rat, or four grains, provided they are without blemish. The pence of cutting and polishing, amounts to about four pounds ore. The value however is far above what is now stated when ey become considerable in size.

The usual method of calculating the value of diamonds, is by uaring the number of carats, and then multiplying the amount the price of a single carat: thus supposing one carat to be 2. a diamond of 8 carats is worth £128. being 8 × 8 × 2.

The famous Pigot diamond weighs $188\frac{1}{2}$ grains.

PHYSICAL PROPERTIES OF DIAMOND.

Diamond is always crystallized, but sometimes so imperfectly, at at first sight it might appear amorphous. The figure of the amond when perfect, is an eight-sided prism. There are also bical, flat, and round diamonds. It is the oriental diamond hich crystallizes into octohedra, and exhibits all the varieties this primitive figure. The diamond of Brazil crystallizes into decahedra.

The texture of the diamond is lamellated, for it may be split cleft with an instrument of well-tempered steel, by a swift ow in a particular direction. There are however some diamonds hich do not appear to be formed of *laminæ*, but of twisted d interwoven fibres, like those of knots in wood. These ex- ed the others greatly in hardness, they cannot be cut or po- hed, and are therefore called by the lapidaries DIAMONDS OF ATURE.

The diamond is one of the hardest bodies known. It resists e most highly tempered steel file, which circumstance renders necessary to attack it with diamond powder. It takes an ex- isite and lasting polish. It has a great refractive power, and ence its lustre, when cut into the form of a regular solid, is

which it precipitates. It has no effect upon the acidity of [illegible]. The rules however cannot extend to [illegible] by the agency

Diamond is not acted upon by acids, or by any oxygen excepted, and this requires a very great heat to produce any effect.

The diamond burns by a strong heat with a [illegible] like other combustible bodies, affording oxygen [illegible] entirely converted into carbonic acid gas during the

It combines with iron by fusion, and converts [illegible] charcoal, into steel, but diamond requires more [illegible] to burn in than common charcoal does, and even [illegible] but slowly, and ceases to burn the instant [illegible] is lowered.

It is considered by modern chemists as PURE CRYSTALLIZED CARBON.

SECT. II.

PROOFS
OF THE
COMBUSTIBILITY OF DIAMOND.

THE combustibility of the diamond is a phenomenon sufficiently interesting to induce us to give an extract of the principal experiments which have served to advance our knowledge upon this subject.

The Emperor Francis I. exposed to a vehement heat, the value of six thousand florins in diamonds and rubies; the diamonds disappeared, but the rubies remained unaltered. These experiments were repeated; and it was ascertained that the diamond lost its polish, scaled off, and was dissipated.

The Grand-duke of Tuscany in 1694 caused experiments to be made by Averoni and Targioni by the mirror of Tschirnhausen, and the diamond disappeared in a few minutes.

These experiments were repeated by the French chemists, Darcet, Cadet, Lavoisier, &c. with equal success. The details of their experiments may be seen in the volumes of the Academy of Sciences, and the Journal de Physique for the year 1772.

Macquer took notice that the diamond dilated, swelled and burnt with a blue flame. Ladriani* mentions an experiment, in which the diamond was fixed to the end of a small iron wire which was heated red hot, and plunged into a vessel filled with oxigen gas. The combustion of the iron communicated itself to the diamond, which burnt in this gas, with a very bright flame.

* Annales de Chem. tom. XI. p. 156.

tely black and of a coally appearance; the instant
lliant and as it were boiling points were distinctly
e black ground. It now began to diminish in
hort time no more than one-fourth was remain-
en withdrawn. It was without any marked sharp
, but still very white, and of a beautiful transpa-
iamond was a second time heated with the solar
venty minutes entirely consumed without any re-
this operation the same phenomena were ob-

f barytes was then introduced over the mercury
ir in which the diamond had been consumed. It
liately milky, the volume of the gas diminished,
of barytes was formed.
ess a greater quantity of carbonic acid was ob-
ould have been produced, had the diamond been
ate as common charcoal. For one part of char-
ring combustion 2.527 of oxigen, and produces
onic acid; but one part of diamond absorbs some-
n four parts of oxigen, and produces five of car-

d of which Guyton effected the complete combus-
ive octohedral crystal. It burned in a tempera-
90 pyrometrical degrees, which in the scale of
nstitutes a difference of from 183° to 1765°.
wise indebted to Dr. Smithson Tennant for some
riments on the nature of the diamond. His paper
shall give an abstract is in the Philosophical Trans-
97. Dr. Tennant has taught us a method of effect-
stion of the diamond in a much easier manner than
ove. He has proved that by means of nitrate of
mbustion may be accomplished in a moderate heat.
r procured a tube of gold, which having one end
l as a retort, to which a glass tube was adapted in
ct the air produced. To be certain that the gold

vessel with pernitric mixture, and that it did not contain
which could occasion the production of carbonic acid,
tube of potash was sealed and decomposed in it, and
washed out with water. The solution was examined
for carbonic acid by appearance of carbonic acid.

The diamond was then burnt in this vessel by means
of potash. When it was thus destroyed, the substance
produced gave a white cloud from lime-water, and on the
addition of nitric acid carbonic acid gas and nitrous gas,
from the decomposition of nitrate of potash partly decomposed
by nitrite of potash.

In order to estimate the quantity of carbonic acid which
was produced by the given quantity of diamonds, two
grains of which I selected were put into the golden
quarter of an ounce of nitrate of potash, the whole
exposed to a strong red heat for about an hour and a half.
The tube was then opened again, the contents were dissolved
in water, and to certify the diamonds had been destroyed

In order to ascertain the quantity of carbonic acid, the
solution was then dissolved, were decomposed by muriatic
Hence muriate of potash and carbonate of lime were
The carbonate of lime was separated from the muri

The combustion of the diamond is effected at three different peratures. At the first and least elevated temperature the mond assumes a grey and black colour; this is the first degree xidation; it is the state of the plumbago and of the antraco- , or incombustible pit-coal.

At the second degree of temperature there is a new, slow and cessive combination of oxigen; it then constitutes the habi- l state of our charcoal.

Supposing therefore we could operate with sufficient precision take from the surface of the diamond, the black matter in pro- tion as it formed, during our experiment for burning it, we uld undoubtedly convert the whole diamond into *charcoal*.

At the third degree of combustion the diamond is wholly con- ted into carbonic acid gas, as we have shown before.

Guyton has likewise converted soft-iron into cast-steel, by ans of the diamond, in the following manner:* A cavity was ed in a block of soft-iron, and a stopper fitted to it of the same tal. Into the cavity was put a diamond, with some filings of block of iron, to fill the remaining space, after which the pper was driven in. In this state the whole was put into a cible and this placed into another. The space between the o crucibles was filled with pure siliceous sand. The external cible was well closed and luted, and the whole exposed to strong ignition of a blast-furnace, by which the metal was ed completely; the diamond disappeared and the iron was s converted into steel.

After all this, it will no doubt be demanded how it happens, t the pure carbon or diamond is so scarce, whilst when com- ed with oxigen in the state of charcoal it is so abundantly persed through nature?

We obtain by our chemical decompositions of bodies charcoal l not diamond. No chemist speaks of our exhaling diamond respiration, but many of charcoal or at least carbonic acid.

* Annales de Chem. XXXI, p. 328.

produce the same effects.

The diamond is advantageously used on account of its hardness in engraving on hard stones and glass, and ornamental pieces. It is also used as an ornament; extreme hardness, the labour of cutting and polishing it with its own dust, render it precious without the capture of fashion.

Before we proceed farther in the description of *gases*, it will be necessary to illustrate the nature of *gases*, together with their properties; for these bodies produces so considerable a number of facts which distinguish some bodies from others, previous acquaintance with them, a great number of experiments illustrative of the properties of air would be unintelligible.

NATURE

AND

FORMATION OF GASES.

PART XIV.

SECT. I.

NATURE OF GASES.

By the word *gases* we distinguish permanently elastic aeriform fluids, or substances which have the appearance of air, that is to say; they are transparent, elastic, ponderable, invisible,* and not condensible into a liquid or solid state by any degree of cold hitherto known.

Some of the gases exist in nature, without the aid of art, and may therefore be collected; others on the contrary, are only producible by artificial means.

All gases are combinations of certain substances, reduced to the gazeous form by the addition of caloric and light. It is therefore necessary to distinguish in every gas, the matter of heat which acted the part of a solvent, and the substance which forms the basis of the gas. Gases are not contained in those

* Oxigenated muriatic acid gas, and nitrous acid gas, are the only exceptions to this rule.

substances from which we obtain them in the state of gas, but owe their formation to the expansive property of caloric.

The bases of some gases are known to us and may be exhibited in an uncombined state; others again are not producible by art.

FORMATION OF GASES.

It has been mentioned before (p. 84.) that the different forms under which bodies appear depend upon a certain quantity of caloric, chemically combined with them. The very formation of gases corroborates this truth. Their production totally depends upon the combination of the particular substances with caloric; and those we call permanently elastic, are only so, because we cannot so far reduce their temperature, as to dispose them to part with it; otherwise they would undoubtedly become fluid or solid.

Water, for instance, is a solid substance in all degrees below 32° of Fahrenheit's scale; above this temperature it combines with caloric and becomes a fluid. It retains its fluidity under the ordinary pressure of the atmosphere, till its temperature is augmented to 212°. It then combines with a larger portion of caloric, and is converted, *apparently*, into gas, or at least into elastic vapour; in which state it would continue if the temperature of our atmosphere was above 212°. Gases are therefore solid substances between the particles of which a repulsion is established by the quantity of caloric.

But as in the gazeous water or steam, the caloric is retained with but little force, on account of its quitting the water when the vapour is merely exposed to a lower temperature, we do not admit steam amongst the class of gases, or permanent aeriform elastic fluids. In gases caloric is united by a very forcible affinity, and no diminution of temperature, or pressure that has ever yet been effected, can separate it from them. Thus the air of our atmosphere in the most intense cold, still remains in the

form state; and hence is derived the essential characters of s, namely; *that they shall remain aeriform, under all varia- s of pressure and temperatures.*'

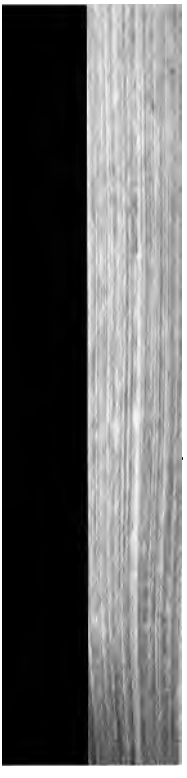
i the modern nomenclature, the name of every substance ting in the aeriform state is derived from its solid base; and term gas is used to denote its existence in this state.

n order to illustrate the formation of gases, or to show in what ner caloric is combined with them, the following experiment serve.

Experiment I.

ut into a retort capable of holding half a pint of water, two ces of muriate of soda, (common salt), pour on it half weight of sulphuric acid and apply the heat of a lamp, a at quantity of gas is produced which might be collected and ained over mercury. But to serve the purpose of this experi- nt let it pass through a glass receiver having two openings, o one of which the neck of the retort passes, whilst from the er a bent tube proceeds which ends in a vessel of water.... fore closing the apparatus, let a thermometer be included in receiver to show the temperature of the gas. It will be found t the mercury in the thermometer will rise only a few degrees, ereas the water in the vessel which receives the bent tube, ll soon become boiling hot.

Rationale....Common salt consists of muriatic acid united soda, on presenting sulphuric acid to this union, a decom- sition takes place. The sulphuric acid unites by virtue of greater affinity to the soda and forms sulphate of soda, or auber's salt; the muriatic acid becomes therefore disengaged, d takes the gazeous form in which it is capable of existing in r temperature. To trace the caloric during this experiment as s our object, we must remark that it first flows from the np to the disengaged muriatic acid, and converts it into gas;



AND

TRANSFERRING THEM FROM ANOTHER.

PREVIOUS to undertaking experime
well for the unexperienced operator t
the dexterous management of collecting
mon air.

If we are desirous of transmitting air
ther, it is necessary that the vessel destin
of water or some fluid heavier than air.
wide mouthed bell-glass or receiver, plu
in the trough in order to fill it, then i
downwards and place it on the shelf of th
one or more of the holes in it.

It will now be full of water and co
mouth remains below the surface of the
in this case the water is sustained in the
the atmosphere, in the same manner as t
in the barometer. It may without diffi

nwards, scarce any of it will enter the glass, because its
ance is opposed by the elasticity of the included air; but if
vessel be turned with its mouth upwards it immediately fills
the air rises in bubbles to the surface. Suppose this opera-
to be performed under one of the jars or receivers which
illed with water and placed upon the perforated shelf, the
vill ascend in bubbles as before, but instead of escaping, it
be caught in the upper part of the jar and expel part of the
r it contains.

this manner we see that air may be emptied out of one ves-
nto another by a kind of inverted pouring, by which means
made to ascend from the lower to the upper vessel. When
eceiving vessel has a narrow neck the air may be poured in
nilar manner through an inverted funnel inserted in its
h.

the air is to be transferred from a vessel that is stopped like
ttle, the bottle must be unstopped with its orifice down-
s in the water; and then inclined in such a manner that its
may come under the perforated excavation of the shelf.
gas will escape from the bottle and passing into the vessel
ied to receive it, will ascend in it, in the form of bub-

whatever manner this operation is performed, the necessity
excavation in the lower part of the shelf may be readily
ived. It is as mentioned before destined to collect the gas
escapes from the vessel, and direct it in its passage to-
the vessel adapted to receive it. Without this excavation
as, instead of proceeding to the place of its destination,
be dispersed and lost.

vessels or receivers for collecting the disengaged gases
be glass cylinders, jars, or bell-glasses of various sizes;
of them should be open at both ends, others should be fit-
ith necks at the top, ground perfectly level, in order that
nay be stopped by ground flat pieces of metal, glass, slate,

&c. others should be furnished with ground stoppers. Some should be graduated into cubic inches, and sub-divided into decimal or other equi-distant parts. Besides these, common glass bottles, tumblers, &c. may be used.

CLASSIFICATION OF GASES.

All the elastic aeriform fluids with which we are hitherto acquainted are generally divided by systematic writers into two classes; namely, those that are *respirable* and *capable of maintaining combustion*, and those that are *not respirable* and *incapable of maintaining combustion*. This division indeed has its advantage; but the term respirable in its physico-logical application has been very differently employed by different writers. Sometimes by the respirability of a gas has been meant its power of supporting life, when repeatedly applied to the blood in the lungs. At other times all gases have been considered respirable which were capable of introduction into the lungs by voluntary efforts, without any relation to their vitality. In the last case, the word respirable seems to us most properly employed, and in this sense it will be used hereafter.

Non-respirable gases are those, which when applied to the external organs of respiration, stimulate the muscles of the epiglottis, in such a manner as to keep it perfectly close on the glottis; thus preventing the smallest particle of gas from entering into the bronchia, in spite of voluntary exertions.

Of respirable gases, or those which are capable of being taken into the lungs by voluntary efforts, according to their conditions, only one has the power of uniformly supporting life, namely, atmospheric air; other gases when respired, sooner or later impair the health of the human constitution, or perhaps occasion death; but in different modes.

Some gases effect *no positive* change in the blood; animals immersed in it, die of a disease produced by the privation of

ospheric air, analogous to that occasioned by their submer-
in water.

thers again produce *some positive* change in the blood, as
ars from the experiments of Dr. Beddoes and Professor Davy.
y seem to render it incapable of supplying the nervous and
cular fibres with principles essential to sensibility and irrita-
y. These gases therefore destroy animal life on a different
ciple.

is obvious therefore that the above classification does not
good in all respects, but is capable of misleading the stu-
. We shall not divide the gases we are going to treat of
different classes; for we do not see the advantage which can
from any division: we shall therefore examine first those
h are simple, the bases of which cannot be exhibited in
nsulated state, namely, oxigen, nitrogen, and hidrogen gas.
shall then consider the combination of these gases with each
r, in order to understand some of the most important phe-
ena in which they are concerned, together with the rest of
ose gases, of which the bases may be exhibited experi-
tally.

The act of its combining with bodies is called *oxidation*, or ox-
cation; and the bodies with which it is combined are called
s.

Oxigen gas is the chief basis of the pneumatic doctrine of che-
stry.

METHODS OF OBTAINING OXIGEN GAS.

We are at present acquainted with a great number of bodies
m which we may, by art, produce oxigen gas. It is most am-
obtained from the oxids of manganese, or mercury; from
ate of potash; from the green leaves of vegetables, and from
enated muriate of potash, or soda. Besides these, there are
reat many other substances from which oxigen gas may be
ured.

In order to procure oxigen gas in a state of great purity,
oxigenated muriate of potash or soda, must be made use of.
h this view put some of the salt into a small earthen or
retort, the neck of which is placed under the shelf of the
matic trough filled with water; and heat the retort by means
lamp. The salt will begin to melt, and oxigen gas will be
ined in abundance and of great purity, which may be collected
preserved over water.

TIONALE...Oxigenated muriate of potash consists of oxige-
d muriatic acid and potash; at an elevated temperature a
mposition of the oxigenated muriatic acid takes place; its
n unites to the caloric and forms oxigen gas. The oxigen-
acid becomes therefore converted into simple muriatic acid,
h remains in the retort united to the potash, in the form
uriate of potash.

Oxigen gas may likewise be obtained from the green leaves
getables.

r this purpose fill a bell-glass with water, introduce fresh
red green leaves under it, and place the bell or receiver
ted in a vessel containing the same fluid; expose the

water and probably carbonic acid, which serve for their
ment; they absorb the hidrogen and carbon of these fl
engaging part of the oxigen in a state of purity. Light
favours this decomposition greatly, it seems to serve for
the oxigen and thus forms it into oxigen gas; in proport
becomes disengaged, the hidrogen becomes fixed in the
and combines partly with the carbon, and partly with th
to form the oil, &c. of the vegetable.

3. Nitrate of potash is another substance frequently
of for obtaining oxigen gas, in the following manner:

Take any quantity of this salt, introduce it into
earthen or glass retort, and fit to it a tube, which
plunged into the pneumatic trough, under the receiver
water. When the apparatus has been properly adjusted
retort gradually till it becomes red-hot; the oxigen ga
be disengaged rapidly.

The gas obtained in this way is also very pure, e
the last portion be kept separate.

RATIONALE...Nitrate of potash consists of nitric
potash. Nitric acid consists again of oxigen and nitr
exposing the salt to ignition, a partial decomposition
takes place; the greatest part of the oxigen of the
unites to caloric, and appears under the form of oxige

gen gas. The weight of the two gases when collected
nd to correspond very exactly with the weight of the
had been decomposed. The residue then left in the
otash.

k oxid of manganese however is generally made use of
ing oxigen gas, on account of its cheapness. This na-
s reduced to a coarse powder; a stone or rather an
is then charged with it and heated. As soon as the
omes ignited, oxigen gas is obtained plentifully.

ALE...Black oxid of manganese is the metal called
e fully saturated with oxigen, together with many
purities; on applying heat, part of the solid oxigen
metal and unites to caloric in order to form oxigen gas,
nder of the oxigen remains united to the metal with a
finity; the metal therefore re-approaches to the metal-
r is found in the state of a grey oxid of manganese.

und of the best manganese yields upwards of 1400 cu-
of oxigen gas, nearly pure. If sulphuric acid be pre-
ded to the manganese, the gas is produced by a less
in a larger quantity; a glass retort may then be used,
eat of a lamp is sufficient.

oxid of mercury yields oxigen gas in a manner similar
manganese.

NALE...This oxid consists likewise of solid oxigen and
the combination of which takes place on exposing mer-
heat of about 610° Fahr. At this degree it attracts
nd becomes converted into an oxid; but if the tempera-
increased to about 1000° the attraction of oxigen is
The oxigen then attracts caloric stronger than it did
ury, it therefore abandons it, and forms oxigen gas.
cury then re-appears in its metallic state. (See p. 50.)
d oxid of lead yields oxigen gas on the same principle.

DECOMPOSITION OF OXIGEN GAS, BY E
DEVELOPEMENT OF METALLIC PROPERTI

Experiment I.

Combustion of phosphorus in oxigen gas.



FILL a bell-glass or receiver with oxigen gas, co
mercury, and introduce a piece of phosphorus through
silver which immediately will rise to the surface of it
fire to the phosphorus by means of a crooked heated
introduced so as to touch it without disturbing the
will burn with a very brilliant flame. A considerable
caloric and light will be liberated, and the whole in
glass will be covered with a white flaky crust, whi
found to be phosphoric acid: and the mercury will hav
considerably.

RATIONALE.—This experiment proves that a decom

weight of the iro

proportion to the qu

the same time lost its

ifferent from those in

employed for the

the metal from each

cohesion or aggregati

iron when heated to a

the equilibrium of the

and solid oxigen being

separate and opposite fo

to remain in the gazeous

the latter power being gr

at the same time its caloric a

consisted, consisting of oxigen and

not an acid, but it is changed

approaching to the acid state, tho

respective properties.

Experiment II.

Combustion of zinc in oxigen ga

Take some turnings of zinc, form a ball of a

ONALE...This experiment is analogous to the former; unites to the oxigen of the gas, at an elevated tempera- d the result is an oxid of zinc.

EXPERIMENT III.

Combustion of arsenic in oxigen gas.

a piece of metallic arsenic, dip it into oil of turpentine, e it in a copper ladle, then set fire to the oil which ad- it by means of a candle, and introduce the ladle into er filled with oxigen gas; the metal will take fire with a thick flame, and the whole receiver will be h white vapours.

NALE...In this experiment arsenic acid is formed by the ombining with the metal.

EXPERIMENT IV.

rrent of oxigen gas be conveyed to filings of metals, burn with great rapidity.

is purpose fill a large bladder with oxigen gas, and adapt be; by pressing the bladder and ejecting the gas on a excavated ignited charcoal, into which filings of metal n put, the metal will burn rapidly.

ings of metals which exhibit the most brilliant appear- those of zinc, copper, antimony, iron, and steel.

OMPOSITION OF OXIGEN GAS BY VARIOUS OTHER SUBSTANCES.

EXPERIMENT I.

ghted wax taper fixed to an iron wire be let down into filled with oxigen gas, it will burn with great splendor.

If the taper be blown out and let down into the vessel [illegible] while the snuff remains red-hot, it instantly relights [illegible] slight explosion, and burns vividly.

EXPERIMENT II.

A piece of the bark of charcoal fastened to a copper [illegible] ignited, and then immersed in the gas, throws out [illegible] sparks.

EXPERIMENT III.

A mixture of nitrate of strontia and charcoal powder, [illegible] viously ignited, burns with a *rose-coloured flame*.

EXPERIMENT IV.

A mixture of one part of boracic acid, and three of charcoal [illegible] burns *green*.

EXPERIMENT V.

One part of nitrate of barytes and four of charcoal powder [illegible] burn with a *yellow flame*.

EXPERIMENT VI.

Equal parts of nitrate of lime and charcoal powder burn *orange-red*.

Those who are desirous of multiplying experiments of this kind, may present to oxigen gas under similar conditions a variety of other combustible substances. The phenomena attending the combustion of many of them are extremely vivid and beautiful; for instance, cotton dipt in oil of turpentine, ardent spirit, resin, camphor, elastic-gum, &c.

HIDROGEN GAS.

PART XVI.

SECT. I.

PROPERTIES OF HIDROGEN GAS.

THIS gas, which was formerly called inflammable air, was covered by Mr. Cavendish, in the year 1768, though it had en noticed long before by the ancients. The famous philoso- ical candle attests the antiquity of this discovery.

Hidrogen gas, like oxigen gas, is a triple compound, consist- g of the ponderable base of hidrogen, (page 138) caloric, and ht. It possesses all the mechanical properties of atmospheric . It is the lightest substance whose weight we are able to imate: when in its purest state, and free from moisture, it is out thirteen times lighter than atmospheric air. It is not fit- l for respiration; animals, when obliged to breathe in it, die most instantaneously. It is decomposed by living vegetables, d its basis becomes one of the constituents of oil, resin, &c. is inflammable, and burns rapidly when kindled, *in contact th atmospheric air or oxigen gas*, by means of the electric ark, or by an inflamed body; and burns when pure with a e lambent flame; but all burning substances are immediately

comes mixed with the atmospheric air of these subter
vities. If a lighted candle be brought in, this mi
explodes and produces the most dreadful effects. It
miners *fire-damp*. It generally forms a cloud in the
of the mine on account of its levity, but does not mi
atmospheric air unless some agitation takes place.
frequently set fire to it with a candle, laying at the
flat on their faces to escape the violence of the shock.
and more safe method of clearing the mine is by lea
tube through the shaft of it, to the ash-pit of a furna
means the gas will be conducted to feed the fire.

Hidrogen gas in whatever manner produced, *alway*
from water, either in consequence of a preceding dec
in which it had been combined in the state of solid
drogen, with one of the substances employed, or fro
position of water actually taking place during the exp

REMARKS...There are instances recorded of a vap
from the stomach of dead persons, which took fire
proach of a candle. We even find accounts in sever
the combustion of living human beings, which app
spontaneous. Dr. Swediaur related some instances
at Warsaw, who having drank abundantly of spirit,

However difficult it may be to give credit to such narratives, it is equally difficult to reject them entirely, without refusing to admit the numerous testimonies of men, who were for the most part worthy of credit. *Citizen Lair* has collected all the circumstances of this nature which he found dispersed in different books and has rejected those which did not appear to be supported by respectable testimony, to which he has added some others related by persons still living. These narratives are nine in number, they were communicated to the philomatic society at Paris, and inserted in the bulletin, Thermidor, An. 5, No. 29.

The cause of this singular phenomenon has been attributed to a developement of hidrogen gas taking place in the stomachs of these individuals.

Citizen Lair believes that the bodies of these people were not burned perfectly spontaneously, but it appeared to be owing to some very slight external cause, such as the fire of a candle, taper, or pipe.

SECT. II.

EXPERIMENTAL PROOFS

OF

THE PROPERTIES OF HIDROGEN GAS.

EXPERIMENT I.

Hidrogen gas is considerably lighter than atmospheric air.

FILL a receiver or wide-mouthed bottle with hidrogen gas, and let it stand for a few minutes with its open mouth upwards exposed to the air. On letting down a lighted candle into the bottle the gas will be found to have escaped, for the candle will burn with its usual splendor.

If another jar filled with the gas be placed with its mouth downwards the air will be prevented from ascending by the bottom and sides of the vessel, as may be proved by inserting a lighted candle, which will be instantly extinguished.

EXPERIMENT II.

Soap bubbles filled with hidrogen gas ascend rapidly.

Fill with hidrogen gas, a bladder, and adapt to it a common tobacco pipe; dip the bowl of the pipe into a lather of soap, squeeze it gently in order to form a bubble, and detach it in the usual manner. These bubbles will rise rapidly into the air; if

ed taper be presented to them, they catch fire and burn
noise.

o a bason of soap-suds a mixture of hidrogen gas and at-
ric air be blown, by means of a bladder and pipe, so as
bubbles over a considerable part of the surface of the
nd a lighted match be then presented to it, the whole
lode with a loud report.

theory of balloons or aerostatic machines is founded on
ty of hidrogen gas. It is sufficient that the weight of the
itself and of the inclosed gas should be lighter than an
ulk of common air, and it must rise till its weight is in
ilibrium with an equal volume of the surrounding me-
The theory of the *Mongolfiers* is very different from this.

Experiment III.

Hidrogen gas extinguishes burning bodies.

an inverted jar filled with hidrogen gas, over the flame
dle and depress the jar at once, so that the lighted wick
wholly surrounded by the gas. The candle will imme-
be extinguished.

Experiment IV.

Hidrogen gas is unfit for combustion.

duce hidrogen gas into a jar filled with mercury; when
rcury is displaced pass up into the gas a piece of tinder
h is affixed a little phosphorus, and apply to the latter a
wire. As soon as the phosphorus is touched with the hot
will melt but will not burn; the gas is therefore unfit
bustion.

level of the water in the pneumatic trough, then apply a lighted taper to the upper extremity of the tube, the gas will take fire and exhibit a candle, which will burn till all the gas is exhausted.

Artificial fire-works may be constructed by filling bladders with hidrogen gas, and connecting them with revolving jets, tubes, &c. bent in different directions and formed into various figures, which are pierced with holes of different sizes. The air being forced through these holes by pressing the bladders, will, when inflamed, exhibit a curious fire-work without noise or smoke.

It is on similar principles that Mr. Cartwright's fire-works were formed.

By the combination of the inflammable property of hidrogen gas and the effects of electricity, a curious philosophical lamp has been invented by *Volta*, which by the turning of a stop-cock only, may instantly be lighted many hundred times: for a particular description of which we refer our readers to Adams's Lectures on Natural Philosophy, vol. II. p. 98.

All these experiments show that hidrogen gas, which is not inflammable when alone, possesses that property when in contact with atmospheric air.

Hidrogen gas burns in proportion as it is environed with a larger quantity of atmospheric air, or oxigen gas. As hidrogen gas, and oxigen, or atmospheric air have a like aggregation, it is possible to mix them in such a manner, as that every particle of each gas shall be contiguous to a particle of the other, in which case they will burn with great rapidity.

Experiment VIII.

Fill a strong bottle capable of holding about four ounces of water in such a manner that there may be one part of hidrogen gas and two of atmospheric air. On applying a lighted taper the mixture will not burn silently, but the whole will ex-

copiously at the time of thunder-storms, is owing to a sudden formation of water in the atmosphere, from the rapid combustion of the hidrogen and oxigen gases fired by an electric spark.

The diminution of hidrogen and oxigen gases by their bases may also be shown in the following manner.

Experiment XI.

Fill a tall jar with oxigen gas, and fill also with hidrogen gas, a bladder furnished with a stop-cock, and with a long brass pipe like the letter S, and drawn out to a fine point. On pressing the bladder a stream of gas will issue from the pipe which may be set fire to and brought cautiously under the inverted jar of oxigen gas. By this intercourse, the stream of hidrogen gas will be burnt in a confined portion of oxigen gas; by continuing the combustion a sufficient time, the water will rise gradually within the jar. On the first impression of the heat, indeed, a small quantity of gas will escape from the jar, which will render it difficult to ascertain what degree of absorption actually takes place. But this loss may be prevented by using a jar with a

points may be distant from each other, within the tube, about one-eighth of an inch or less. Into this tube standing in water, two parts in bulk of hidrogen gas, and five parts of atmospheric air, is transferred. The tube is then to be firmly held, and an electric spark is passed, by means of the conductors, through the mixture of the gases; an immediate explosion takes place, the volume of the gases will be diminished, and the water will ascend in the tube; for the whole of the hidrogen gas is consumed, and likewise all that part of the common air which consisted of oxigen gas, and there is formed a quantity of water equal in weight to these two bodies.

RATIONALE...The hidrogen gas robs the atmospheric air of the whole portion of oxigen gas it contained, this mixture being fired by the electric spark disappears and forms water. The residue therefore indicates the quantity of nitrogen gas which was contained in the given bulk of atmospheric air with considerable accuracy.

REMARK...If mixed in the proportion of one part in bulk of the former, and two parts of the latter gas, or more accurately, 85 parts by weight of oxigen gas, and 15 of hidrogen gas, and then exploded over water, the volume of the gases disappears, and the exploding tube in which they were contained, becomes completely filled with water, on account of the total vacuum which had been formed.

If the explosion be made in a close vessel, or over mercury, a quantity of water is always produced, equal in weight to the gases employed.

This water must be composed of the two gases; for it did not previously exist in the vessel, and no other substance besides the gases was introduced. Water then is composed of oxigen and hidrogen; and the combustion of hidrogen is nothing but the act of its combination with oxigen.

It has been with great plausibility conjectured that detonations in the air, or claps of thunder, are similar effects of the combustion of hidrogen and oxigen gas, and that the rain which falls so

weak nitric acid. If the heat of a lamp not exceeding 80° Fahr. be then gently applied the gas will be speedily obtained.

RATIONALE....Animal substances are composed of nitrogen, carbon, hidrogen and oxigen. On adding nitric acid the equilibrium of the respective affinities is destroyed, the nitrogen gas becoming separated.

That the nitric acid does not furnish the nitrogen gas is obvious, from its saturating after its action as large a quantity of alcali as before, consequently it could not have suffered any alteration.

REMARK...The fibrous part of animal matter is that which affords the most nitrogen gas; next to this all the concretive parts, such as the clot of blood; next to that, albuminous matter, such as the serum and white of eggs; gelatinous substances afford the least.

3. Nitrogen gas may likewise be obtained by causing oxigenated muriatic acid gas to be received in a vessel containing liquid ammonia.

RATIONALE...Ammonia consists of hidrogen and nitrogen. The hidrogen of the ammonia unites to the oxigen of the oxigenated muriatic acid and forms water, heat is evolved, the nitrogen becomes free, and the oxigenated muriatic acid becomes converted into simple muriatic acid.

Other methods of obtaining nitrogen gas will be given in the next Part.

mall animal, such as a mouse or bird, be immersed in it instantly dies.

Experiment IV.

en gas is capable of combustion with oxigen, at a high temperature.

a barometer tube, the diameter of which is about the t of an inch. Shut one of its ends with a cork, through le of which passes a small wire, with a ball of metal at . Fill the tube with mercury and invert it into a bason uid. Throw up into the tube as much of a mixture of of nitrogen gas and 87 parts of oxigen gas, as will fill ches. Through this gas, by means of the wire in the ss a number of electric sparks; the volume of the gas diminishes, and in its place will be found nitrous acid.

Experiment V.

ure of nitrogen gas and oxigen gas, produces artificial atmospheric air.

uce into a bell-glass filled with water, four parts of ni- s and one of oxigen gas; after shaking the mixture well an air will be formed greatly resembling that of our at- ; for if a lighted taper or any other burning substance ed into this fluid, it will burn in the same manner as it atmospheric air; it may be breathed with safety, and onfined in it will live as long as in an equal quantity of ric air.

K...Though we are not capable of producing in this an air absolutely the same as that of the atmosphere, is not to be attributed to our ignorance of the quantity



This may be proved by putting a quantity of lir
a tube filled with the gas and shaking it. The tr
the lime-water will not be injured.

ATMOSPHERIC AIR.

PART XVIII.

WHATEVER has been hitherto stated relative to the different kinds of aeriform fluids, is chiefly important, because the knowledge of them is necessary to enable us to comprehend the nature of that gazeous fluid in which we are plunged the moment we are born, and in which we exist. This fluid which surrounds the earth to a considerable, but unknown height above its surface, is called

THE ATMOSPHERE.

In treating of the different aeriform fluids which have hitherto been the subject of our consideration, it was necessary in some measure to anticipate the present, and to intimate that the air of our atmosphere is not, as was formerly supposed, a simple or homogeneous fluid, but that in reality it is composed of two distinct fluids, called oxigen gas and nitrogen gas.

Strictly speaking, the air of our atmosphere is however not so simple a substance as to be formed only of two ingredients. Besides the two substances of which it is composed, it contains a small portion of another gazeous fluid, called *carbonic acid.*

It is also well known that a large portion of water is generally contained in the atmosphere, besides a great variety of substances which are subject to evaporation, and which are capable of existing in an aeriform state at the usual temperature.

SECT. I.

MECHANICAL EXAMINATION

OF

ATMOSPHERIC AIR.

By mechanical examination we would be understood to mean such properties as are connected with sensible changes of motion, and which indicate the presence and agency of moving or mechanical powers. They are therefore strictly the subject of mathematical discussion; admitting of measure, number, and direction; notions indeed purely mathematical. But as those mechanical properties characterise, or are peculiar *to all kinds* of elastic aeriform or gaseous fluids, no objection occurs to us against the propriety of considering them here briefly.

The mechanical properties of atmospheric air, are GRAVITY, ELASTICITY, INVISIBILITY, and DILATABILITY.

GRAVITY OF ATMOSPHERIC AIR.

Experiment I.

To prove the weight of the air, a pair of common bellows may serve; thus, for instance, if we stop the nozle and secure the valve-hole closely, having first blown or squeezed all the air out of them, we shall find that a considerable force is requisite for separating the boards. They are kept together by the pressure of the air which surrounds them, in the same manner as if they were immersed in water.

Experiment II.

In like manner, if we stop the end of a syringe, after its piston has been pressed down quite to the bottom, and then endeavour to draw it up, we shall find a considerable force necessary, *viz.* about 15 pounds for every square inch of the section of the syringe. Exerting this force we can draw up the piston and hold it there; but the moment we cease pulling, the piston rushes down again. We feel something as it were drawing in the piston, but it is solely the weight of the incumbent air pressing it; and this obtains in every position of the syringe; because the air is a fluid and presses in every direction; nay, it presses on the syringe as well as on the piston; for if the piston be suspended by its ring on a nail, it will require a weight to draw down the syringe, equal to that which is necessary to draw up the piston, and as soon as the syringe is freed from the weight it will spring up to its place again.

That the air presses equally in all directions becomes obvious from the following experiments:

Experiment III.

In a tall phial let an orifice be made about three inches from the bottom; stop this orifice. Through a cork in the neck of the phial, insert a long tube open at each end, and let the lower end be below the orifice in the side of the phial. The mouth of the phial being closed up about the tube, pour water into the tube till it is full. Upon opening the orifice, the water will be discharged, till its surface in the tube is level with the orifice; after which it will cease to flow, because the external lateral pressure of the air, balances the perpendicular pressure upon the water in the tube.

arst the bladder with a loud report. In a similar situation plate of glass may be broken.

Experiment X.

glass bulb with a long neck filled with water be put in- into a vessel of the same fluid, placed under a receiver, e latter be exhausted, on re-admitting the air its pressure he surface of the water in the vessel, will cause the fluid up in the bulb.

Experiment XI.

a plate, called a *transferrer*, the air be exhausted from receiver, and then water be admitted through a pipe ans of a stop-cock, the water will be pressed up and form tain.

Experiment XII.

e air be exhausted from a vessel and by means of a cock , and the vessel be weighed while it is empty, and again d when the air is re-admitted; the difference will be the of the quantity of air the vessel contains.

Experiment XIII.

a glass tube, about three feet long, and closed at one end, ercury; then insert the open end in a cup or vessel of the luid. The mercury in the tube will be kept suspended, pressure of the external air on the surface of that which e open cup: when this pressure is removed by placing nder a receiver, and exhausting it; the mercury in the ll sink, and rise again on re-admitting the air.

he gravity of the air depends the ascent of water in pumps, s, &c. and the phenomena of the barometer.



By the pressure of the air the sucking of animal
supplies, and many other phenomena are explained
rons to be noticed here.

Thus the doctrine of the gravity and pressure of
established by the most unexceptionable evidence
titled to assume, *a priori*, all its legitimate consequ

SPECIFIC WEIGHT OF ATMOSPHERIC

A bulk of atmospheric air that is equal to an E
when taken near the level of the sea, and at abo
weighs at a medium about 10 grains, and the same
water at the same temperature, weighs about 14
Hence rain-water is about 914 times specifically heav

The pressure of the air is equal to about 15 pou
every square inch, and this pressure is the same in
tion. A square mile contains 27,878,400 square
earth's surface in round numbers is 200,000,000 s
and therefore the pressure of the atmosphere circum
the whole surface of the earth is 12‴,043,468″,800,0
pounds.

and more ponderous fluid. We are not sensible of the
of the air, on account of its being equally applied on
ide, besides, that we have been accustomed to support it
ur earliest infancy. Sensations to which we have at all
been habituated, are not felt; we can perceive no differ-
here we have no standard to judge of variations.

ELASTICITY OF ATMOSPHERIC AIR.

t the air is an elastic fluid, or capable of compression and
ion may be proved by a great number of experiments.
the elasticity or spring of the air produces the same effect
pressure, because the pressure is equal to the compressing
for if it were less, it is clear it would yield and be more
essed; were it greater, it would not be so much reduced;
ion and re-action are always equal.
air-gun, the effects of which are generally known, illus-
the elasticity of the air and shows the compression it is
tible of.
oot-ball or bladder filled with air, rebounds from any hard

elasticity of the air is also proved by fish and other ani-
The former have received from nature various means of
; among these are an air-bladder, which they contract or
at pleasure, and by this double property they ascend or
nd in the water.

INVISIBILITY OF AIR.

nospheric air when confined in vessels is absolutely invisi-
nd cannot be distinguished from the glass which contains it.
es this property to the ready passage it affords to the rays
ht, which are refracted without being reflected; and it is
ore destitute of colour; though some philosophers have
ided themselves that they discovered large masses of it to be

SECT. II.

CHEMICAL EXAMINATION

OF

ATMOSPHERIC AIR.

CHEMISTRY affords two general methods of investigating the constituent parts of bodies, Analysis and Synthesis; that both of these methods can be applied in the investigation of the nature of atmospheric air, we shall endeavour to prove.

From some ingenious experiments Lavoisier has demonstrated as stated already, that the air of our atmosphere is not a simple homogeneous fluid, but consists of two elastic aeriform bodies, possessing very different properties, one of which is capable of supporting combustion and animal life, called oxigen gas, and the other is destructive to animals and extinguishes fire, called nitrogen gas. The atmosphere contains some other gazeous fluids, or bodies capable of being dissolved or suspended in it, but in small quantities. Late experiments seem to have proved that a minute quantity of carbonic acid is always contained in the air, for alcalies become effervescent; strontia, barytic, and lime-waters acquire a pellicle on being exposed a sufficient time to the action of the air, even upon the highest mountains. Water is likewise always found in the atmosphere, but the quantity of these matters is extremely minute; and experiments are still wanting to prove satisfactorily that carbonic acid gas and water are always and every where present in our atmosphere.

[illegible] constituents must therefore be considered as the two substances of which atmospheric air is composed.

Since the oxygen and the nitrogen of the atmospheric air cannot be separated from each other by any of the means with which chemists are acquainted, the analysis of that fluid is usually effected by exposing it to the action of those substances which have the property of abstracting its oxygen. The oxygen being separated, the nitrogen is left behind, and the proportion of which it may be ascertained by the diminution of bulk, which the air has undergone. It is easy to determine the exact proportions of the component parts.

ANALYSIS OF ATMOSPHERIC AIR.

EXPERIMENT I.

Procure a small piece of wax taper, about four inches long, and fasten it to the bottom of a wine bottle and hold it by the [illegible] Set fire to the taper and introduce it [illegible] push in the cork in order [illegible] from without. The flame of



is heat it gradually over a lamp. As soon as the phos-
has been heated to a certain degree it takes fire, burn-
h a flame and a dense white smoke; but as it soon
o burn, heat the vessel again, after it has cooled, to try
more combustion will take place; lastly, let the flask

vessel was perfectly dry, the inside of it will be lined
white coating, but if it was moist this coating will be dis-
nto a fluid, (phosphoric acid.)
every thing has returned to its former temperature,
the flask inverted under water and draw out the cork;
er will ascend in it, hence a portion of the air it con-
as disappeared.
water which has risen shows what quantity of air has
st, if its cubic contents be compared with that of the
essel. The portion of air thus vanished will in general
to about one fifth of the whole that had been submitted
xperiment.
flask, after the phosphorus was inclosed in it, be accu-
eighed, and again after the combustion has taken place
rence of weight will be found.
water forced up into the vessel changes the blue tincture
ge-juice to red; an evident proof of the presence of an

emaining air is unfit for burning phosphorus or other bo-
imals are likewise suffocated in it.
ONALE...Phosphorus is a simple body; on being heated
es the atmospheric air, that is to say, the equilibrium of
nity subsisting between the compound parts of the air,
the oxigen and the nitrogen is broken, on account of
sphorus having a greater attraction for the oxigen than
ogen has, it therefore unites to it, and becomes by this
converted into an acid, called phosphoric acid: the
rt of the atmosphere remains behind. The light and

rent lengths, affix tapers to the extremities of
of a flat dish or
the tapers which should
over the whole with a
. The tapers will burn during the
time the highest one wi
extinguished, and the w
next taper in height wil
others will be extinguished
at the same time consider
.

Explanation. The philosophy of this experim
The burning bodies effect in the
analysis. They ab
of this principle, leavin
Combustion therefore consists in th
combustible body, the basis of
and the caloric set at liberty

SECT. III.

EUDIOMETRY,

OR

METHODS OF ASCERTAINING THE PURITY OF ATMOSPHERIC AIR.

NO sooner was the composition of the atmosphere known, than it became an enquiry of importance to find out a method of ascertaining with facility and precision, the relative quantity of oxigen gas contained in a given bulk of atmospheric air.

The instruments in which the oxigen gas of a determined quantity of air was ascertained, received the name of EUDIOMETERS, because they were considered as measurers of the purity of air. They are however more properly called OXIMETERS.

The eudiometers proposed by different chemists, are the following:

1. PRIESTLEY's EUDIOMETER.

The first eudiometer was made in consequence of Dr. Priestley's discovery, that when nitrous gas is mixed with atmospheric air over water, the bulk of the mixture diminishes rapidly, in consequence of the combination of the gas with the oxigen of the air, and the absorption of the nitric acid thus formed by the water.

fities of oxigen which they contain, provided th
parts of air be susceptible of variation.

Dr. Priestley's method was to mix together equa
and nitrous gas in a low jar, and then transfer
into a narrow graduated glass tube about three
order to measure the diminution of bulk. He
diminution by the number of hundredth parts rema
suppose he had mixed together equal parts of ni
air, and that the sum total was 200 (or 2.00): su
seldom when measured in the graduated tube to a
(or 1.04), and of course that 96 parts of the wh
poured, he denoted the purity of the air thus tried

Remark.—This method of analysing air by mi
gas is liable to many errors. For the water over w
periment is made, may contain more or less carb
mospheric air, or other heterogeneous substance.
gas is not always of the same composition, and is p
by the nitrous acid which is formed; the figure of
many other circumstances are capable of occasionin
differences in the results.

Fontana, Cavendish, Ladriani, Magellan, Von
Dr. Falconer have made series of laborious experi

2. SCHEELE's EUDIOMETER

Is merely a graduated glass cylinder, containing a given quantity of air, exposed to a mixture of iron filings and sulphur formed into a paste with water. The substances may be made use of in the following manner:

Make a quantity of sulphur in powder, and iron filings, into a paste with water, and place the mixture in a saucer or plate, over water, on a stand raised above the fluid; then invert over it a graduated bell-glass, and allow this to stand for a day or two. The air contained in the bell-glass will gradually diminish, as will appear from the ascent of the water.

When no further diminution takes place, the vessel containing the sulphuret must be removed, and the remaining air will be found to be nitrogen gas, which was contained in that quantity of atmospheric air.

RATIONALE....The moistened sulphuret of iron has a great affinity to oxigen, it attracts and separates it from the atmospheric air, and the nitrogen gas is left behind; the sulphur during the experiment is converted into sulphuric acid, which unites to the alcali and forms sulphate of potash.

The air which is exposed to moistened iron and sulphur gradually becomes diminished on account of its oxigen combining with a portion of the sulphur which becomes converted into sulphuric acid, and its nitrogen remains behind. The quantity of oxigen contained in the air examined becomes thus obvious, by the diminution of bulk, which the volume of air submitted to examination has undergone.

REMARK...The only error to which this method is liable, is that the sulphuric acid which is formed acts on the iron and produces hidrogen gas, which joins to the nitrogen remaining after the absorption, and occasions an incorrect result; and hence it is that the absorption amounts in general to 0.27 parts, although the true quantity of oxigen is no more than from 0.21 to 0.22.

Take a glass cylinder closed at the top, and whose capacity st be measured into sufficiently small portions by a graduated le fixed on it. If the instrument be destined solely for exining atmospheric air, it will be sufficient to apply the scale m the orifice of the cylinder down to about half its length, or sketch that scale on a slip of paper pasted on the outside of the e, and to varnish it over with a transparent varnish.

This half of the eudiometrical tube is divided into fifty equiant parts, which in this case indicate hundredth parts of the ole capacity of the instrument.

nto this vessel full of atmospheric air put a piece of dry phosrus (one grain to every twelve cubic inches) close it air-tight beat it gradually, first the sides near the bottom and afterrds the bottom itself. The phosphorus will take fire and burn idly. After every thing is cold, invert the mouth of the eumeter-tube into a bason of water or mercury, and withdraw cork. The water will ascend in proportion to the loss of oxn gas the air has sustained, and thus its quantity may be astained.

Analogous to this is

5. SEGUIN's EUDIOMETER,

Which consists of a glass tube of about one inch in diameter, eight or ten inches high, closed at the upper extremity. It illed with mercury and kept inverted in this fluid in the merial trough. A small bit of phosphorus is introduced into it, ich on account of its specific gravity being less than that of rcury, will rise up in it to the top. The phosphorus is then lted by means of a red-hot poker, or burning coal applied to outside of the tube. When the phosphorus is liquified, small rtions of air destined to be examined, and which have been viously measured in a vessel graduated to the cubic inch or into ins, are introduced into the tube. As soon as the air which

diminished by $\frac{3}{100}$ gives us the bulk of the nitrogen gas air examined; which bulk subtracted from the original of air, gives us the proportion of oxigen gas contained The same allowance must be made in the eudiometer of n.

7. DAVY's EUDIOMETER.

til very lately the preceding processes were the methods termining the relative proportions of the two gases which ose our atmosphere.

ne of these methods though very ingenious are so ex- ly slow in their action, that it is difficult to ascertain the e time at which the operation ceases. Others have fre- ly involved inaccuracies, not easily removed.

e eudiometer we are now going to describe, is not only free these objections, but the result it offers is always con- it requires little address, and is very expeditious; the ap- us is portable, simple and convenient.

ke a small glass tube graduated into one hundred equi-dis- parts; fill this tube with the air to be examined, and plunge o a bottle or any other convenient vessel, containing a co- ated solution of green muriate or sulphate of iron, strongly gnated with nitrous gas. All that is necessary to be done move the tube in the solution a little backwards and for- s; under these circumstances the oxigen gas contained in ir will be rapidly absorbed, and condensed by the nitrous n the solution, in the form of nitrous acid.

B. The state of the greatest absorption must be marked, e mixture afterwards emits a little gas which would alter result.

his circumstance depends upon the slow decomposition of nitrous acid (formed during the experiment), by the green of iron, and the consequent production of a small quantity riform fluid (chiefly nitrous gas); which having no affi-

nity with the red muriate, or sulphate of iron, produced by the combination of oxigen, is gradually evolved, and mingled with the residual nitrogen gas.

The impregnated solution with green muriate is more rapid in its operation than the solution with green sulphate. In cases when these salts cannot be obtained in a state of absolute purity, the common sulphate of iron of commerce may be employed. One cubic inch of moderately strong impregnated solution, is capable of absorbing five or six cubic inches of oxigen, in common processes; but the same quantity must never be employed for more than one experiment.

GENERAL REMARKS.

In all these different methods of analysing air, it is necessary to operate on air of a determinate density, and to take care that the residuum be neither more condensed nor dilated than the air was when first operated on. If these things are not attended to, no dependance whatever can be placed upon the result of the experiments, how carefully soever they may have been performed. It is therefore necessary to place the air before and after the examination into water of the same temperature. If this and several other little circumstances have been attended to, for instance a change in the height of the barometer, &c. we find that air is composed of 0.22 of oxigen gas, and 0.78 of nitrogen gas by bulk. But as the weight of these two gases is not exactly the same, the proportion of the component parts by weight will differ a little; for as the specific gravity of oxigen gas is to that of nitrogen gas as 135 : 115, it follows that 100 parts of air are composed *by weight* of about

74 nitrogen gas
26 oxigen gas

100

The air of this metropolis examined by means of Davy's eudiometer, was found in all the different seasons of the year to con-

21 of oxigen, and the same was the case with air taken at
on, and Highgate; in the solitary cells in Cold-bath-fields
and on the River Thames. But the quantity of water
ied in a given bulk of air from these places differed consi-
y.

ing thus ascertained the nature and the proportion of the
nent parts of air, it remains only to enquire in what man-
se component parts are united. Are they merely mixed
r mechanically, or are they combined chemically? Is air
anical mixture or a chemical compound? Philosophers
t first to have adopted the former of these opinions, if
cept Scheele, who always considered air as a chemical
und. But the supposition that air is a mechanical mixture,
means agrees with the phenomena which it exhibits. If
e gases were only mixed together, as their specific gravity
rent, it is scarcely possible that they would be uniformly
in every part of the atmophere. Since therefore air is in
ces composed of the same ingredients, exactly in the same
tions, it follows that its component parts are not only
but actually combined. When substances differing in
gravity combine together, the specific gravity of the
und is usually greater than the mean. This holds good also
spect to air. The specific gravity, by calculation, amounts
0.00119, whereas it actually is 0.0012.

must therefore consider air as a chemical compound.
the reason that it is in all cases the same, notwithstanding
merous decomposing processes, to which it is subjected.
reathing of animals, combustion, and a thousand other
ons, are constantly abstracting its oxigen, and decompo-
. The air thus decomposed or vitiated, no doubt ascends
atmosphere, and is again, by some unknown process
verted into atmospheric air. But the nature of these
s is at present concealed under an impenetrable veil.

CARBONIC ACID GAS.

PART XIX.

SECT. I.

CARBONIC acid gas is the first elastic aeriform fluid that was known. We find that the ancients were in some measure acquainted with it. Van Helmont called it the gas of Must, or of the vintage, or *gas sylvestre*.

We are indebted to Dr. Black of Edinburgh for the knowledge of some of the most remarkable properties of this fluid. In the year 1755 he discovered the affinity between this gas and alcalies: and Bergman, in 1772, proved that it was an acid.

PROPERTIES OF CARBONIC ACID GAS.

Carbonic acid gas is invisible. It extinguishes flame. It is fatal to animal life. It exerts powerful effects on living vegetables. Its taste is pungent and acid. Its energy, as an acid, is but feeble, although distinct and certain. Neither light, nor caloric seem to produce any distinct effect upon it, except that the latter dilates it. It mixes without combining with oxigen gas. It unites with water slowly. These two fluids, after considerable agitation, at last combine, and form a sub-

colder the water and the greater the pressure applied, rbonic acid gas will be absorbed. The water im- ith it sparkles upon agitation; it has a pungent, aci- , and reddens tincture of litmus. Heat again disen- s from the water. This gas precipitates lime, stron- ytes, from their solutions in water. It is greedily all the alcalies. It undergoes no alteration by light. veight is to that of atmospheric air as 1500 to 1000. oured out of one vessel into another. It is not acted gen, nor is it altered by any of the simple combus- at common temperatures; but phosphorus, iron, capable of decomposing it, when assisted by heat.

DS OF OBTAINING CARBONIC ACID GAS.

gases, carbonic acid gas is that perhaps, which is the greatest abundance throughout nature. It is ee different states:...1*st*, In that of gas; 2*dly*, In ure; and 3*dly*, In that of combination. The vari- s for obtaining it are the following:

to a common gas-bottle or retort, a little marble, ne-stone, and pour on it sulphuric acid, diluted with es its weight of water, an effervescence will ensue, acid gas will be liberated, which those who have an may collect over mercury; but a mercurial appa- absolutely necessary, since the gas may be collected if it is to be used immediately when procured.

LE...In this instance the carbonic acid is disengaged te of combination, and reduced to the aeriform state e marble, lime-stone, or chalk consists of this acid on presenting to it sulphuric acid, a decomposi- lace, the sulphuric acid has a greater affinity to the e carbonic acid has, it therefore unites to it, and te of lime, disengaging at the same time the car-

animal is immediately killed if his nose be thrust

bonic acid, existing naturally in the state of gas, may ed by filling bottles with water and emptying them tmosphere of this gas; the gas takes the place of the fills the bottles, which must then be corked.

c acid gas is likewise formed during fermentation; on f its great weight it occupies the apparently empty upper part of the vessel in which the fermenting pro- ng on. It may in this case be collected in a manner that above.

c acid gas is also obtained during the reduction of xids, and during the deflagration of nitrates with com- odies, as shall be noticed in another part of this

SECT. II.

EXPERIMENTAL PROOFS

OF

THE PROPERTIES OF CARBONIC ACID GAS.

EXPERIMENT I.

Carbonic acid gas is unfit for combustion.

TO prove this, set a vessel filled with this gas, with its mo upwards, and let down a lighted candle; the candle will be mediately extinguished, and the smoke remaining in the gas render its surface visible, which by agitation may be thr into undulating waves.



y extinguished, but the glowing wick will be re-lighted in the containing oxigen gas, and burn with a dazzling splendor.

ATIONALE...This experiment confirms a fact already estaed; namely, that oxigen gas is much fitter for combustion atmospheric air; and is also a most complete proof that carbic acid gas extinguishes light.

EMARK...This property of carbonic acid gas may be advantausly made use of to learn whether the air in a newly sunk ll, in subterraneous caverns, pits, mines, vaults, cellars, and like, may be approached without danger.

EXPERIMENT III.

Carbonic acid gas is fatal to animal life.

Put a mouse or other small animal into a vessel filled with this s, and cover the vessel to prevent the contact of atmospheric r. The animal will die in a minute or two.

REMARK...It is this gas which has produced so many fatal acdents, at the opening of cellars or vaults, in which wine, cyder, beer has been suffered to ferment.

The famous lake of Averno, where Virgil placed the entrance Hell, yields so large a quantity of carbonic acid gas, that birds nnot fly close over it with impunity.

EXPERIMENT IV.

Carbonic acid gas is heavier than atmospheric air.

Let a long glass tube proceeding from a gas-bottle in which rbonic acid gas is disengaged, be twice bent at right angles. et the open end of the longest leg reach to the bottom of a jar, rfectly dry within, and standing with its mouth uppermost. he carbonic acid disengaged will expel the atmospheric air from ie jar, on account of its greater specific gravity. When the

Cyder, perry, ale, champagne, &c. owe their briskness to the bonic acid gas which they contain, and which becomes rapidly ngaged in order to assume the gazeous form, on removing cork of the bottle; it is this also which produces froth, &c.

Experiment VI.

Carbonic acid gas when combined with water possesses acid properties.

This may be shown by dipping into water saturated with rbonic acid gas, a piece of litmus paper, or by mixing with about an equal quantity of infusion of litmus. The blue co- r of the paper or infusion will be changed to red.

Experiment VII.

Carbonic acid gas precipitates lime, barytic, and strontia water.

Let the stream of carbonic acid gas, as it proceeds from the engaging vessel, pass into either of these solutions, the fluid, ugh perfectly transparent before, will instantly grow turbid, carbonate of lime, barytes, or strontia will be formed.

f equal measures of water impregnated with carbonic acid , and either of the above solutions be mixed, a similar effect l be produced.

Experiment VIII.

Carbonic acid gas exerts powerful effects on living vegetables.

Water impregnated with carbonic acid gas proves highly nu- tive, when applied to the roots of plants. But on the con-

carbonic acid is decomposed. The carbonaceous ... becoming a component ... which ... the carbonic acid solution is there ... In the latter instance no s ...

Experiment IX.

Carbonic acid gas rapidly absorbed by

... with this gas over water, and when ... containing a concentrated solution of potas ... solution was ... the tube, and if ... with ...

... This absorption of the gas, is ow ... the carbonic acid gas, and forming ... carbonate of potash

LIGHT CARBONATED HIDROGEN GAS.

PART XX.

SECT. I.

was mentioned before that hidrogen gas has the property of lving various substances in minute quantities, such as car- sulphur, phosphorus, &c. The nature of the gas now r consideration furnishes an instance of this kind. Light nated hidrogen gas is hidrogen gas holding charcoal in so- n. There are several combinations of this kind of gas ob- d by different processes, which differ in their properties, and proportion of their constituent principles.

PROPERTIES OF LIGHT CARBONATED HIDROGEN GAS.

ht carbonated hidrogen gas has a fetid odour. It is neither ed nor altered by water. It is inflammable and burns denser and deeper coloured flame than hidrogen gas. It lterable by acids or alcalies, and by water. Its specific

idrogen gas. In order to obtain the latter in a state of
the whole must be mixed with lime-water or with a
alcaline solution. The carbonic acid gas will be absorbed
carbonated hidrogen gas left behind in a pure state.

ONALE...The production of this gas in this manner is the
f a partial analysis of the wood. It proves that wood
solid hidrogen, carbon and oxigen. When the intensity
eat has reached a certain degree, a part of the charcoal
ith part of the oxigen and produces carbonic acid, which
s of caloric is melted into the gazeous state and forms
acid gas; at the same time a part of the hidrogen of
d combines with another portion of carbon and caloric,
ns carbonated hidrogen gas.

RK...The flame of burning wood, &c. is the inflamed
ted hidrogen gas, liberated on the application of caloric
bodies.

arcoal is in general made use of for obtaining light car-
hidrogen gas. For this purpose put some moistened
into an earthen retort, apply heat, and increase it till
rt becomes ignited; gas will be evolved, consisting
f carbonic acid gas, and partly of light carbonated hidro-
which may be separated as before.

ONALE...In this case a decomposition of the water takes
y means of the charcoal. The oxigen forsakes its hi-
and unites to part of the charcoal at this temperature,
ms carbonic acid gas, in conjunction with caloric; the
l hidrogen assisted by caloric, dissolves another portion
arcoal, and forms with it light carbonated hidrogen gas.
ight carbonated hidrogen gas may be formed in a direct
by dissolving charcoal in hidrogen gas. This may be ef-
y directing the rays of the sun collected in the focus of
, upon a small piece of charcoal placed on mercury, in a
filled with hidrogen gas.

SECT. II.

EXPERIMENTAL PROOFS OF THE PROPERTIES OF LIGHT CARBONATED HIDROGEN GAS.

Experiment I.

Light carbonated hidrogen gas is inflammable.

THIS may be shown by filling a tumbler or any wide-mouth vessel with this gas, and setting fire to it, by means of a light taper. It may likewise be shown by burning it in the manner directed for burning hidrogen gas. The colour of the flame this gas is of a deeper blue than that of hidrogen gas.

Experiment II.

Light carbonated hidrogen gas is heavier than hidrogen gas

Soap bubbles blown with it do not ascend like those filled with pure hidrogen gas, but descend like those filled with common air. A jar filled with carbonated hidrogen gas, held inverted for a few minutes exchanges its contents for common air.

Experiment III.

Decomposition of light carbonated hidrogen gas, by means of oxigen gas.

Mr. Cruikshank found (Nicholson's Journal, April 1801) that six measures of carbonated hidrogen gas obtained from moistened charcoal, when mixed with four of pure oxigen gas, over mer-

exploded violently by the electric spark, and became reduced to 12½ measures, or that there was an increase of 2½ measures nearly. On admitting lime-water the volume diminished rather more than two measures; the residue amounted to 10 on which nitrous gas had no effect. Two measures of the residuary gas fired with one of oxigen, became reduced to one, which was carbonic acid gas. Hence the whole residuary gas would require about 5½ measures of oxigen to saturate it, and produce 5 measures of carbonic acid gas.

Experiment IV.

Decomposition of light carbonated hidrogen gas, by means of oxigenated muriatic acid gas.

The effects of the oxigenated muriatic acid gas upon all the hydro-carbonates is remarkable. Mr. Cruikshank observed, that if pure oxigenated muriatic acid gas, be mixed with these kinds of gases over water, although no action should be perceptible at first, yet in twenty-four hours a complete decomposition and change of principles takes place.

For instance, introduce into a bottle filled with and inverted over water, one measure of pure light carbonated hidrogen gas well washed, mixed with two measures of fresh prepared pure oxigenated muriatic acid gas. On the first contact of the oxigenated muriatic acid gas a white cloud and some diminution will be perceived, which will soon cease. The bottle must then be stopped and suffered to remain inverted in water for about twenty-four hours. If the bottle be then uncorked under water, the fluid will instantly ascend into it, and the gas will occupy about .43 parts of a measure, the diminution being 2.57 measures. On mixing the residuary gas with lime water .09 parts will become absorbed.

bonated hidrogen gas, and forms water; anothe
the charcoal and produces carbonic acid gas; a s
combines with another portion of charcoal, an
oxid of carbon, and the oxigenated muriatic a
losing its excess of oxigen, becomes converted
riatic acid gas.

Remark...According to Mr. Cruikshank's
cubic inches of light carbonated hidrogen ga
wetted charcoal, weighed 14.5 grains; they re
inches (22.4 grains) of oxigen to saturate them.
yielded 40 cubic inches (19 grains) carbonic aci
of water. Hence this gas consists of nearly 4 o
hidrogen, and 9 of water.

HEAVY CARBONATED HIDROGEN GAS.

PART XXI.

SECT. I.

HIS gas was first brought into notice by a society of Dutch nists, consisting of Deiman, Troostwyk, Bond, and Lau- urgh. They observed in this gas the particular property, when it was combined with oxigenated muriatic acid gas certain proportion, the elastic form of both fluids became royed, and an oil was produced; for which reason they d it *Olefiant gas*.

PROPERTIES OF HEAVY CARBONATED HIDROGEN GAS.

leavy carbonated hidrogen gas is not absorbed or altered water. Its weight compared with common air is as 909 to 0. It has a disagreeable fetid odour, different from that ight carbonated hidrogen gas. It burns with a strong com- flame, similar to that of a resinous oil. When mixed with

not affect it. When made to pass through an
it does not diminish in volume, but loses the pr
oil with oxigenated muriatic acid gas. Elect
through it, dilate, and likewise deprive it
When passed through an ignited porcelain tu
drogen gas, mingled with carbonic acid, and ca
When passed through a tube with sulphur in fi
hidrogen gas is obtained, and charcoal deposit
with oxigen gas, or when passed through a r
with oxid of manganese, carbonic acid gas is fo

METHODS OF OBTAINING HEAVY C
HIDROGEN GAS.

Heavy carbonated hidrogen gas is obtained
alcohol by sulphuric acid, at high temperature
tained in abundance when alcohol or ether is
red-hot earthen tube. Sulphuric ether mixed wi
and subjected to heat, also affords it, but in a le
The Dutch chemists observed, that if the
spirit or ether be made to pass through a glas
component parts of the earthen tube, namely, a

and heavy carbonated hidrogen gas will be extricated without the application of external heat. When a moderate heat is applied, the action is very violent, and the gas is liberated very copiously, and may be received over water.

The gas obtained is always mixed with a considerable quantity of sulphureous acid gas, from which it may be freed by agitating it in contact with lime-water, or a solution of potash.

Remark....In this operation the heat ought to be regulated with great care, and the retort holding the mixture ought to be very capacious, otherwise the matter will be forced over into the receiver. The heat of a candle or lamp is sufficient.

Numerous experiments by different chemists have proved, that this species of carbonated hidrogen gas contains a larger quantity of carbon in solution than the former. This becomes obvious from the gas losing the property of forming oil by being made to pass through an ignited tube, for it then deposits charcoal, and becomes converted into light carbonated hidrogen gas.

The Dutch philosophers suppose that the disposition to form oil depends on the proximity of the constituent moleculæ of the gas; and the loss of this property they suppose to be owing to the separation of these moleculæ, by the introduction of a greater quantity of caloric.

Heavy carbonated hidrogen gas, they say, is converted into light carbonated hidrogen gas whenever a process is executed which increases the distance subsisting between its component parts. In this way the attraction between the particles of the hidrogen and carbon is diminished, which happens whenever the gas is made to pass through ignited tubes, capable of acquiring a high temperature, or by strongly electrifying it.

Either heavy or light carbonated hidrogen gas may therefore be obtained indiscriminately from the same substances, namely, ether or ardent spirit. Their difference arises from the different methods of treating these fluids, and is constantly reducible to this; that in forming the first gas, a less quantity of caloric, acts upon the mass, and a compound is formed in which the

hidrogen and charcoal are more concentrated, and more disposed to form oil by the addition of oxigen; whereas by more strongly heating the ardent spirit or ether, they become more completely decomposed; their constituent parts are removed to a greater distance, by a greater proportion of caloric being introduced between them, and the simultaneous attraction which might be disposed to form oil with oxigen, is so far diminished that they are no longer capable of that transition, therefore no oil can be formed.

Hence we perceive likewise why the specific gravity of the heavy carbonated hidrogen gas, when it loses its property of forming oil, becomes diminished.

We do not however agree with the Dutch chemists, that either the alumine, silex, or earthen tube serves to form this gas, as they assert, while glass tubes only afford the common carbonated hidrogen gas. These different effects certainly do not arise from the causes which are assigned to them. They seem to arise from a less degree of heat having been applied in all the cases where the heavy carbonated hidrogen gas was produced, and a greater degree in all those which present the light carbonated hidrogen gas.

Mr. Nicholson observed* that when ardent spirit is burnt in the lamp of Argand, and the lower aperture or air-passage of the lamp is kept open, the flame of the spirit is as usual faint and bluish, resembling that of carbonated hidrogen gas; but if the air-passage be obstructed by slowly applying the palm of the hand, or any more suitable obstacle the flame becomes more and more luminous, like that of oil, until in the progress of obstruction the aperture is so much closed that the combustion begins to decay for want of air. By a proper adjustment of the aperture, the spirit may be made to burn with a constant luminous white internal flame. In this case the temperature is precisely such as to produce the olefiant gas.

* Journal of Natural Philosophy, &c. May 1797, p. 55.

SECT. II.

EXPERIMENTAL PROOFS OF THE PROPERTIES OF HEAVY CARBONATED HIDROGEN GAS.

THE properties of this gas being similar to those of the other hidro-carbonates, it is unnecessary to exhibit experimental proofs of them; those already advanced under the head of light carbonated-hidrogen gas, will explain them all with the exception of its characteristic property of producing oil with oxigenated muriatic acid gas which shall be inserted here with a few other interesting remarks.

EXPERIMENT I.

Production of oil by the mixture of heavy carbonated hidrogen gas, with oxigenated muriatic acid gas.

Take a glass tube, send up into it three parts of *fresh prepared* heavy carbonated hidrogen gas, and add to it gradually four parts of *fresh prepared* oxigenated muriatic acid gas. After each addition of the gas, shake the mixture; an absorption will take place, caloric will be liberated, and the tube will become filled with white vapours. When the gases have totally disappeared an oil of a pearl grey colour will be deposited.

This oil is heavier than water, its odour is agreeable and penetrating, its taste is rather sweet. It becomes yellow by exposure to air.

Experiment II.

Conversion of heavy carbonated hidrogen gas, into light carbonated hidrogen by combustion with oxigen gas.

Let equal parts of fresh prepared heavy carbonated hidrogen gas, and oxigen gas be mingled together in a detonating tube, and a spark be passed through it, a momentary expansion will take place, the tube will become lined with a fine black soot of charcoal, and the heavy carbonated hidrogen gas will thus be converted into light carbonated hidrogen gas.

Mr. Cruikshank found that 100 cubic inches of carbonated hidrogen gas, obtained from alcohol, weighed 16 grains. It required 118 cubic inches of oxigen to saturate it, and produced 75 cubic inches of carbonic acid. This gas therefore consists of 7 carbon, 1.9 hidrogen and 7 water.

The same quantity of gas, obtained from ether, weighed 30 grains. It required for saturation 170 cubic inches of oxigen and produced 108 of carbonic acid. Hence this gas consisted of 9 carbon, 3 hidrogen, and 8 water.

One hundred cubic inches of carbonated hidrogen gas, obtained from camphor, weighed 21 grains. They consumed 176 cubic inches of oxigen, and produced 116 of carbonic acid; this gas consisted therefore of 11 carbon, 2 + hidrogen, and 8 or 9 water.

In the preceding estimate the weight of 100 cubic inches of common air, under the mean pressure of the atmosphere, and at the temperature of 55° is estimated at 31 grains. The quantity of carbon in carbonic acid at $\frac{1}{3}$ of the whole nearly, and the proportion of oxigen to hidrogen in water as about 85 to 15.

From the result of these experiments we perceive that the carbonated hidrogen gases obtained from various substances differ in their composition. This has given rise to the next species of gas.

GAZEOUS

OXID OF CARBON.

PART XXII.

AZEOUS oxid of carbon was first described by Dr. Priestley, mistook it for a hidro-carbonate.

ith the true nature of it we have been only lately acquainted. s first proved to be a peculiar gas, by Mr. Cruikshank of lwich, who made it known to us, as such, in April 1801, gh the medium of Nicholson's Journal for that month. Se- additional properties of this gas were soon afterwards no- by Desormes, Clement and others. Gazeous oxid of carbon s an intermediate substance between the pure hidro-car- es and carbonic acid gas; but not being possessed of acid rties Mr. Cruikshank has called it, conformable to the rules chemical nomenclature, *gazeous oxid of carbon*, for it con- of oxigen and carbon rendered gazeous by caloric.

ough the gazeous oxid of carbon has some of the properties iar to the common hidro-carbonates, the following cha- istic properties sufficiently prove that none of those at pre- known are similar to it. We are therefore entitled to der it as a gas peculiar to itself.

SECT.

PROPERTIES OF GAZEOUS OXID OF CARB

ZEOUS oxid of carbon is considerably li
dro-carbonates. It is lighter than comme
n of 22 to 23. When mingled with com
does not explode, but burns with a lam
e product is carbonic acid. It is very li
; it is void of taste and odour. A mixtur
ous oxid of carbon and 8 of oxigen gas, f
electricity, diminishes to 8 of its volume equal o
rts, which is carbonic acid gas. It contain
basis of that fluid. It is exceedingly noxi
instantly, when breathed for a few minut
giddiness and fainting, when breathed for a few minu
any effect upon it. Neither a few minutes
arbon and nitrogen gas are equal quantities
the tube is filled with oxigen gas, heat
of nitrogen gas which is oxidated by charcoal. Water
tube, it is oxidated by charcoal, and passed quantities
hogen gas and carbonic acid gas. If a
chief constituent part of coal gas. It is sparingly
difficulty escape. It is not conve
capable of dan
in bulk.
of burni
effect on

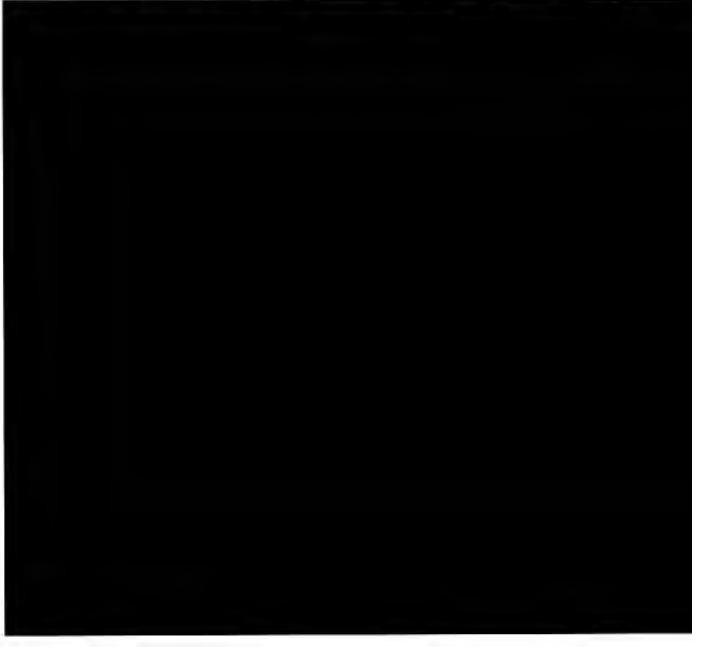
being thus deprived of part of its oxigen, becomes converted into a new inflammable gas called gaseous oxid of carbon.

Remark.—Upon the whole therefore we have to consider this gas as holding the same relation to pure hidro-carbonates and carbonic acid gas, which nitrous gas or nitrous oxid does to pure nitrogen and nitrous acid.

Tin, and probably various other metals, when mingled with charcoal, are capable of producing gaseous oxid of carbon in a similar manner.

2. Gaseous oxid of carbon may also be obtained in the following manner:

Take equal quantities of scales of iron separated in forging, (grey oxid of iron) and charcoal powder previously heated to redness; mix them together, introduce the mixture into a coated glass retort, or gun-barrel, and apply heat gradually; as soon as the retort becomes of a dull red heat, gas is produced in great abundance. It consists of about one part of carbonic acid gas and four of gaseous oxid of carbon. In order to separate the carbonic acid gas, it must be suffered to stand over slaked lime or agitated with lime-water; the carbonic acid gas will be absorbed, and what remains behind is pure inflammable gaseous



zeous oxid of carbon. Those oxids which retain their oxigen most obstinately yield most of the latter, and those which part with it readily afford most carbonic acid gas. The latter comes over chiefly at the beginning and the former towards the end of the process.

Inferences...From these various facts there can no longer remain any doubt but that the carbonic acid, under certain elevations of temperature, may be decomposed by any fixed substance having a considerable affinity with oxigen, and that with regard to the metals, those succeed the best which have the greatest attraction for acids or oxigen, as is the case with zinc. Upon the whole we may conclude that there are but two distinct combinations of carbon and oxigen capable of assuming and maintaining the form of gas. For although the gazeous oxid of carbon may be obtained in a great variety of ways, by direct composition, as well as during the decomposition of the carbonic acid, yet when pure, it is exactly the same substance, having the same specific gravity, requiring the same portion of oxigen to saturate it, and producing the same quantity of carbonic acid, as Mr. Cruikshank* has sufficiently proved experimentally to what the different results of impure gases are owing.

One hundred cubic inches of gazeous oxid of carbon, obtained from iron filings and carbonate of lime or barytes, previously ignited, according to Mr. Cruikshank weigh 30 grains. They require 40 cubic inches (13.6 grains) of oxigen for saturation, and form 92 cubic inches (43.2 grains) of carbonic acid, and no water is produced. Hence the 100 cubic inches of gazeous oxid of carbon consist of 21 + oxigen 8.6 carbon.

One hundred cubic inches of the same gas obtained from charcoal and metallic oxids, weigh 30 grains. They require 44 cubic inches (15 grains) of oxigen for saturation, and yield 76 cubic inches (35.5 grains) of carbonic acid, and afford (on account of the hidrogen contained in the charcoal) about 8 grains of water.

* Nicholson's Journal, Sep. 1801, p. 210.



of 8.5 grains of carbon and 34.6 of oxigen nearly
tity of oxigen employed in the experiment was o
hence the difference between 34.6 and 13.6 or
have been originally contained in the oxid. It
appear that the gazeous oxids in their purest stat
igen and carbon, in the proportion of 21 to 9 n
with caloric.

Upon the whole, we consider as mentioned b
ous oxid of carbon as holding the same relation to
carbonates and carbonic acid, which nitrous gas,
does to pure nitrogen and nitrous acid.

SULPHURATED HIDROGEN GAS.

PART XXIII.

SECT. I.

PROPERTIES OF SULPHURATED HIDROGEN GAS.

SULPHURATED hidrogen gas possesses the properties of an acid; for when absorbed by water its solution reddens vegetable blues; it combines also with alcalies, earths, and with several metallic oxids. Sulphurated hidrogen gas possesses an extremely offensive odour, resembling that of putrid eggs. It kills animals, and extinguishes burning bodies. When mixed with oxigen gas, or atmospheric air, it is inflammable. Mingled with nitrous gas it burns with a yellowish green flame. It is decomposed by ammonia, by oxigenated muriatic acid gas, and by sulphureous acid gas. It has a strong action on the greater number of metallic oxids. Its specific gravity to common air is as 1106

to 1000. It is composed, according to Thenart, of 70.857 sulphur and 29.143 hidrogen. It has the property of dissolving a small quantity of phosphorus.

METHODS OF OBTAINING SULPHURATED HIDROGEN GAS.

1. Take dry sulphuret of potash, put it into a tubulated retort lodged in a sand bath, or supported over a lamp, direct the nick of the retort under a receiver placed in the pneumatic trough; then pour gradually upon the sulphuret diluted sulphuric, or muriatic acid; a violent effervescence will take place, and sulphurated hidrogen gas will be liberated. When no more gas is produced spontaneously, urge the mixture with heat by degrees till it boils, and gas will again be liberated abundantly.

The water made use of for receiving it should be heated to about 80° or 90°; at this temperature it dissolves little of the gas, whereas if cold water be made use of, a vast quantity of it is absorbed.

RATIONALE...Though sulphur makes no alteration on water, which proves that sulphur has less attraction for oxigen, than hidrogen has, yet if sulphur be united to an alcali, this combination decomposes water whenever it comes into contact with it, though the alcali itself has no attraction either for oxigen or hidrogen.

The formation of this gas explains this truth. On adding the sulphuret of potash to the water, this fluid becomes decomposed, part of the sulphur robs it of its oxigen, and forms with it sulphuric acid, this generated acid unites to part of the alcali and forms sulphate of potash. The liberated hidrogen dissolves another part of the sulphur, and forms with it sulphurated hidrogen; the basis of this gas, which is retained by the separated portion of the alcali. The sulphuric acid added now extricates it from the alcali, and makes it fly off in the form of gas.

The mixture in the retort therefore contains an alcaline sulphure properly so called, or the simple combination of sulphur with alcali; sulphate of potash, and lastly, sulphurated hidrogen gas dissolved in the alcaline sulphure, or an hidrogenated sulphuret.

REMARK...Diluted muriatic acid is best adapted for the production of sulphurated hidrogen gas from alcaline sulphurets. If nitric acid be made use of it must be much diluted. Sulphuric acid yields little gas, unless assisted by heat. When the proportion of sulphur in the sulphuret exceeds that of the alcali, the dense sulphuric acid poured upon it emits sulphuric acid gas much loaded with sulphur. All the rest of the acids may be made use of for decomposing the sulphurets.

2. When iron and sulphur are united together, they afford a large quantity of sulphurated hidrogen gas on submitting them to the action of heat, in contact with water.

Melt together in a crucible equal parts of iron filings and sulphur; the product is a black brittle mass called sulphuret of iron. Reduce this to powder, and put it with a little water into a tubulated retort; add diluted muriatic acid, and apply a gentle heat, till no more gas is disengaged.

RATIONALE...The philosophy of this experiment is analogous to the former. Part of the oxigen of the water unites to part of the sulphur, and forms sulphuric acid, another part oxidates the iron, which dissolved by the acid forms sulphate of iron: the hidrogen of the water unites to another part of the sulphur, and forms sulphurated hidrogen, which becomes gazeous by the addition of caloric.

3. Sulphurated hidrogen gas may also be obtained by heating an alcaline sulphuret, with the addition of water, without the affusion of an acid.

RATIONALE...In this case the water is also decomposed; its hidrogen unites with part of the sulphur, and forms sulphurated hidrogen, the oxigen of the water unites with another part of the sulphur and produces sulphuric acid, which joins to the alcali

SECT. II.

EXPERIMENTAL PROOFS

OF THE

PROPERTIES OF SULPHURATED HIDROGEN GAS.

EXPERIMENT I.

Sulphurated hidrogen gas is absorbed by water.

FILL a bottle with sulphurated hidrogen gas, and keep it inverted in a bason of cold water; an absorption will take place which may be accelerated by agitation. The water which has absorbed a quantity, has the fetid odour of the gas. It is not decomposed by exposure to the air; but the gas is gradually separated and carried off without decomposition. Water impregnated with sulphurated hidrogen gas slightly reddens blue vegetable colours.

REMARK...It is this gas which gives to the mineral waters of Harrogate and Aix-la-Chapelle their peculiar smell. Such waters may therefore be artificially imitated by impregnating pure water with this gas, and adding the other constitutent parts to it.

EXPERIMENT II.

Sulphurated hidrogen gas is inflammable in contact with oxigen gas.

Mix equal parts of sulphurated hidrogen gas and oxigen gas over water, and apply a lighted taper; a smart detonation will take place, and both gases will disappear.

RATIONALE...Part of the oxigen unites to the hidrogen of the sulphurated hidrogen gas; another part joins to the sulphur suspended in this gas, hence the products after combustion are sulphureous acid and water.

EXPERIMENT III.

Sulphurated hidrogen gas mingled with nitrous gas burns with a yellowish-green flame.

If three parts of sulphurated hidrogen gas be mixt with two nitrous gas the mixture may be inflamed, and burns with a yellowish-green flame; the vessel becomes lined with a coat sulphur.

RATIONALE...The explanation of these phenomena are analogous to the rationale of the next experiment.

EXPERIMENT IV.

Sulphurated hidrogen gas is decomposed by atmospheric air

Introduce into a bell-glass, half filled with sulphurated hidrogen gas, an equal quantity of atmospheric air, a diminution will take place, sulphur will be precipitated, and nitrogen left behind.

RATIONALE...The oxigen of the atmospheric air has a greater affinity for hidrogen than the sulphur of the sulphurated hidrogen gas has; they therefore unite and form water, and the sulphur becomes deposited.

REMARK...On this principle it is, that water holding sulphurated hidrogen gas in solution lets fall sulphur on exposure to the open air; and hence arises the sulphur seen deposited in the channels, and in the neighbourhood of sulphurated or as they are commonly called, hepatic waters.

Experiment V.

ted hidrogen gas becomes quickly absorbed by alcaline solutions.

y be proved by filling a tube with the gas, and invert-
bason containing some concentrated solution of potash.
ill be absorbed and the potash will acquire colour,
l other peculiar properties.
nbination is called *hidro-sulphuret of potash*; it is a
compound.
...Hitherto only the alcalies and some of the earths
combined with sulphurated hidrogen gas. These com-
colourless while kept in close vessels, but when ex-
r, they soon acquire colour. This change is produced
composition of part of the sulphurated hidrogen gas
The hidrogen combines with the oxigen of the air,
water, while the sulphur is disengaged, and thus
e colour.
phurated hidrogen gas may again be expelled from
binations in the same ratio it had been absorbed, by
n of an acid. It may also be disengaged by heat.

Experiment VI.

ted hidrogen gas and sulphureous acid gas decompose each other.

lphurated hidrogen gas and sulphureous acid gas are
gether over mercury, the volume of the gases becomes
, and sulphur is deposited on the sides of the vessel
lerable quantity.
hese gases are dissolved in water, they mutually un-
ame decomposition. If suitable quantities are taken,
f both fluids disappears instantly.

RATIONALE...The hidrogen of the sulphurated hidrogen g
has a greater affinity for the oxigen of the sulphureous acid g
than the sulphur has; they therefore unite and form wate
the sulphur of both is deposited.

REMARK...If concentrated nitrous acid be poured cop
into water holding sulphurated hidrogen gas in solution,
phur is likewise deposited. Hence nitrous acid is used as a
to detect the presence of sulphurated hidrogen gas in he
waters.

EXPERIMENT VII.

Combination of sulphurated hidrogen gas and ammonia.

Fill a glass jar with fresh prepared sulphurated hidrogen
confined over mercury, and add to it gradually ammoniacal
a dense white vapour will instantly appear; both gases wil
nish, and a white saline compound will be formed, being hi
genated sulphuret of ammonia.

EXPERIMENT VIII.

*Oxigenated muriatic acid gas, and sulphurated hidrogen g
likewise decompose each other.*

Fill a cylindrical vessel over water with oxigenated mur
acid gas, keep it over that fluid and mingle it with sulphur
hidrogen gas; at the instant the gases come in contact
each other, their bulk will be diminished, and the vessel bec
lined with sulphur.

RATIONALE...The oxigen of the oxigenated muriatic acid
unites partly to the sulphurated hidrogen, and partly to the
phur dissolved in that gas; hence water and sulphuric acid
formed; the oxigenated muriatic acid gas being robbed of
oxigen becomes converted into simple muriatic acid, and
sulphur which escaped the action of the oxigen is precipitate

Experiment IX.

Decomposition of sulphurated hidrogen gas by the electric spark.

Fill a detonating tube over water with sulphurated hidrogen s, and pass the electric spark through it, the volume of the s will become diminished and sulphur be precipitated.

Experiment X.

Sulphurated hidrogen gas acts strongly on the greater number of metallic oxids.

Dip a slip of paper into a solution of silver, lead, bismuth, ercury, tin, &c. and expose it to the action of sulphurated hi-rogen gas, the paper will instantly become blackened. Writings erformed with these solutions are invisible when dry, but be-ome visible when immersed in a bottle filled with this gas.

Rationale...In this instance the hidrogen of the gas abstracts he oxigen from these bodies, and causes them to re-approach o the metallic state; at the same time, the sulphur contained in he gas combines with the metal thus regenerated and converts into a sulphuret.

phosphorus; phosphorated hidrogen gas will
take fire at the surface of the fluid, so long as
of the water is made, with considerable rapi
produced in this process burns with a more l
that obtained in the usual manner, probably
taining a larger quantity of hidrogen. The ex
theless brilliant; for the gas is disengaged
which cover the whole surface of the fluid
themselves rapidly, new ones are produced,
resembles a well of fire.

Remark...For the success of this experim
that the water, during the action of its decom
siderably heated, which may be effected by a
sulphuric acid, and that the phosphorus be
derable quantity. Half a part of phospho
pieces, one of granulated zinc, three of conc
acid, and five of water, answer this purpose e

Phosphorated hidrogen gas is also produce
air which burns at the surface of certain sprin
is called *burning springs* and the *ignis fatu*
which glide along burying-grounds, or places
ters are putrifying, consist of hidrogen gas,

SECT. II.

EXPERIMENTAL PROOFS OF THE PROPERTIES OF PHOSPHORATED HIDROGEN GAS.

EXPERIMENT I.

Phosphorated hidrogen gas takes fire on coming into contact with atmospheric air.

THIS may be evinced by charging a small retort with potash, phosphorus, and water, in the manner mentioned before, applying heat and dipping the mouth of the retort into a bason of water. The bubbles of air which come from the retort and pass through the water will burst with a slight explosion and produce flashes of fire in the circumambient air. A circular dense white smoke rises horizontally like a ring, enlarging itself continually, and forming a sort of *corona* extremely beautiful if the air be perfectly tranquil.

The finest effect is produced when the flashes of gas succeed each other but slowly.

RATIONALE...We have noticed before, that phosphorated hidrogen gas, is nothing but hidrogen gas holding phosphorus in solution. When this gazeous fluid is presented to the atmos-

pour, it unites to the phosphoric acid produced
tutes the circular crown of smoke which rises li

If a wide-mouthed phial be filled with phosp
gas and left in that situation over mercury, the
when suffered to escape into the air by inclinin

Remark....This last is a hazardous experim
often burst to pieces; it is therefore necessar
with a cloth in order to avoid dangerous events.
bottle may be used for this purpose with safety.

Experiment II.

Accension of phosphorated hidrogen gas b
origen gas.

Fill a receiver with oxigen gas and convey int
of phosphorated hidrogen gas. At the instan
the gases, a brilliant flash of fire takes place, a
a report.

The rationale of this experiment is analogous

Remark...Great caution is necessary in perfo

Experiment III.

Accension of phosphorated hidrogen gas, by means of oxigenated muriatic acid gas.

If fresh-prepared phosphorated hidrogen gas and oxigenated muriatic acid gas are mingled together over mercury, a considerable detonation takes place, accompanied with a lambent green flame, and dense white vapours.

Rationale...All that happened in the last experiments takes place in this instance. The oxigenated muriatic acid gas is robbed of its oxigen, and becomes converted into simple muriatic acid gas; and water and phosphoric acid are produced. The evolved heat inflames the phosphorus which was dissolved in the gas.

Remark...For the success of this experiment it is essential that both gases are fresh prepared. The receiver in which the mixture is made should be very strong, in order to guard against accidents.

Experiment IV.

Phosphorated hidrogen gas burns with a green light in nascent oxigenated muriatic acid gas, under the surface of water.

Put into an ale-glass, or Florence flask, one part of phosphoret of lime, broken into pieces of the size of a pea (*not in small fragments or in powder,*) and add to it half a part of oxigenated muriate of potash. Fill the vessel with water, and bring carefully into contact with the materials at the bottom of the fluid, three or four parts of concentrated sulphuric acid. This may be most conveniently done, by letting the acid fall through a long-necked funnel, reaching to the bottom of the vessel, or by causing it to pass down the sides of it. As soon as the decom-

lose their elasticity; plates of yellow matter are deposited on the sides of the vessel, which take fire on hot iron, first in the manner of phosphorus, and afterwards with the characters of sulphur.

RATIONALE...It follows from this experiment that the hidrogen is the only substance which combines with the oxigen in these circumstances, since the gases lose their fluidity and deposit respectively the sulphur and phosphorus contained in them.

EXPERIMENT VII.

Phosphorated hidrogen gas is decomposed by vivid light.

Though phosphorated hidrogen gas may be kept over mercury in the dark, for any length of time unaltered, this is not the case if the gas be exposed to light. If a bottle filled with this gas, be painted partly black, or surrounded with black paper, and then exposed to the light of the sun, the union of the phosphorus and hidrogen will be broken, and the phosphorus will be found crystallized at those parts through which the rays of light were suffered to pass, and the hidrogen gas will be left behind.

NITROUS GAS.

PART XXV.

It is not decomposable by water, though 100 cubic inches of this fluid when freed from air, absorb about 11.8 cubic inches of gas. This solution is void of taste; it does not redden blue vegetable colours; the gas is expelled again when the water is made to boil or suffered to freeze. It has no action on nitrogen gas even when assisted by heat. It is decomposed by several metals at high temperatures.

Its specific gravity, when perfectly pure, is to that of atmospheric air as 1.093 to 1.

Ardent spirit, saccharine matters, hidro-carbonates, sulphureous acid and phosphorus have no action on it. It is not sensibly changed by the action of light. Heat dilates it. It rapidly combines with oxigen gas at common temperatures, and converts it into nitrous acid. Atmospheric air produces the same effect but with less intensity. It is absorbable by green sulphate, muriate and nitrate of iron, and decomposable by alcaline, terrene, and metallic sulphurets, and other bodies that have a strong affinity for oxigen; but it is not capable of combining with them chemically, so as to form saline compounds. From the greatest number of bodies which absorb it, it may be again expelled by the application of heat.

It communicates to flame a greenish colour before extinguishing it; when mixed with hidrogen gas it acquires the property of burning with a green flame. It is absorbable by nitric acid and renders it fuming.

When exposed to the action of caloric in an ignited porcelain tube, it experiences no alteration, but when electric sparks are made to pass through it, it is decomposed and converted into nitrous acid, and nitrogen gas. Phosphorus does not shine in it. It is composed of 56 parts of oxigen and 44 nitrogen.

METHODS OF OBTAINING NITROUS GAS.

1. Put into a small proof or retort, some copper wire or pieces of the same metal, and pour on it nitric acid of commerce di-

TIONALE...Ammonia consists of hidrogen and nitrogen, its
gen combines with the oxigen which is given out by the ig-
manganese, and forms water, its nitrogen unites at the
time to another portion of the oxigen and constitutes the
is gas.

EMARK...There is a cause of deception in this experiment,
ast which the operator ought to be on his guard, lest he
ld conclude no nitrous gas is formed, when in reality there
considerable quantity. The ammonia, notwithstanding every
caution will frequently pass over undecomposed. If the re-
er in the pneumatic trough is filled with water, great part of
will indeed be presently absorbed; but still some portion of
ill mix with the nitrous gas formed in the process. Upon ad-
ing the atmospheric air, the nitrous gas will become decom-
ed, and the red nitrous fumes instantly unite with the alcali.
e receiver is presently filled with white clouds of nitrate of
monia; and in this manner a wrong conclusion may easily be
wn from the want of the orange colour of the nitrous fumes.
considerable quantity of nitrous gas may have been formed,
yet no orange colour appear, owing to this circumstance;
therefore it is easy to understand how a small quantity of
rous gas may be most effectually disguised by the same cause.
Dr. Milner* also obtained nitrous gas, by passing ammonia-
gas over sulphate of iron deprived of its water of crystalliza-
n.

* Phil. Trans. LXXIX, p. 300.

SECT. II.

EXPERIMENTAL PROOFS

OF

THE PROPERTIES OF NITROUS GAS.

EXPERIMENT I.

Nitrous gas decomposes atmospheric air.

IT was mentioned before that nitrous gas greedily attracts ox
gen gas and atmospheric air. We shall demonstrate this fact a
show at the same time that during this union, an acid is pr
duced.

Pass up into a cylindrical glass vessel, over water, about o
measure of nitrous gas and two of common air; the two flu
will speedily unite, red fumes will be produced, and the volu
of the two combined gases will be diminished. A considera
degree of heat will be perceived, the water will rise in the c
linder and absorb the red vapours. When the two gases h
been mixed in due proportion, nothing remains at last but
nitrogen gas of the atmospheric air. Usually 16 measures
common air are requisite to destroy completely $7\frac{1}{2}$ measures
nitrous gas; this however varies according to the purity of
airs.

RATIONALE...The nitrous gas in this experiment decompo
the atmospheric air; it takes the oxigen from the nitrogen

ters with it and forms nitrous acid; the nitrogen is therefore
e behind; the heat which is generated is the caloric which
pt the gases in solution which now becomes liberated.

If instead of atmospheric air, oxigen gas be substituted, this
enomenon will be still more striking. If a pint of pure oxigen
be mixed with two of nitrous gas the redness will be much
eater, and the volume of the gases almost entirely disappear.

REMARK...Upon the property which nitrous gas has of absorb-
the oxigen of the atmosphere, Priestley and Fontana found-
the construction of their eudiometers already mentioned.

EXPERIMENT II.

Proofs that an acid is produced during the mixture of nitrous gas and atmospheric air or oxigen gas.

Paste a slip of litmus paper within a glass jar, near the bottom,
ed into the jar, filled with and inverted in water, pass as much
itrous gas, previously well washed, as will displace the fluid
low the level of the paper; the blue colour of the paper will
main unaltered, but on sending up atmospheric air or oxigen
s, it will immediately change its blue colour to red. A sure
roof that an acid has been formed.

That it is nitrous acid which is produced by the union of ni-
ous gas and oxigen gas, may be evinced in the following

EXPERIMENT III.

Into a jar filled with and inverted over mercury, put a small
antity of solution of pure potash, and afterwards measures of
xigen and nitrous gases separately, and in proper proportion, as
ng as an absorption takes place. On removing the solution
om the jar and evaporating it in a glass bason, crystals of salt
ill be formed which exhibit all the properties of nitrate of
otash.

Experiment IV.

Nitrous gas is absorbed by nitric acid, to which it gives new characters.

Let nitrous gas pass as it is liberated from the materials which afford it, into a bottle containing colourless nitric acid, the acid will first become yellow, then green, next orange-coloured, and at last dark olive-coloured and fuming.

Rationale...The change of colour depends on the absorption of different quantities of nitrous gas. Priestley found that 100 parts of nitric acid of a moderate strength, absorbed in two days 90.29 of nitrous gas. He informs us that when about seven parts were absorbed, the acid assumed an orange colour; when eighteen parts were absorbed, a green colour; and that when the 90.29 were combined, it became red and fuming.

Remark...If the olive-coloured acid be diluted with water, it becomes blue; the orange-coloured when united with water becomes emerald-green; and a large quantity of water renders either of them colourless.

Experiment V.

Nitrous gas which has been absorbed by nitric acid may be expelled again from this fluid.

This may be shown by gently heating the acid coloured in the before-going experiment till it becomes limpid. In this experiment light should be excluded.

Rationale...The nitrous gas absorbed by the acid has a greater affinity for caloric than the nitric acid has; this property therefore is here employed for disengaging the nitrous gas which rendered the acid fuming.

Experiment VI.

Nitrous gas tinges the flame of burning bodies green.

Fill a wide-mouthed bottle with a mixture of one part of nitrous gas, and four of hidrogen gas; set fire to it with a lighted taper, and the mixture will burn with a green flame.

If a lighted taper be immersed in nitrous gas, it exhibits a green flame before the taper becomes extinguished.

Experiment VII.

Nitrous gas is unfit for maintaining the combustion of the greater number of burning bodies.

Fill a receiver with nitrous gas, and let down into it a burning taper; the taper will instantly be extinguished; the same thing will happen to ardent spirit, oils, &c. though burning with a vivid flame.

That nitrous gas however is capable of supporting the combustion of other bodies will be obvious from the following experiments:

Experiment VIII.

Accension of pyrophorus in nitrous gas.

Place some new-made pyrophorus in a copper spoon, and introduce it into a receiver filled with nitrous gas; the pyrophorus will instantly take fire and the volume of the gas will become diminished.

Rationale...The pyrophorus effects a real analysis of the gas, it subtracts its oxigen and leaves its nitrogen behind; hence if the remaining air be examined it will be found that it renders

lime, or barytic water turbid, and that it undergoes no further diminution when mingled with oxigen gas; it is therefore a mixture of carbonic acid and nitrogen gas.

Experiment IX.

Nitrous gas maintains the combustion of phosphorus when introduced in a state of actual inflammation.

Though phosphorus may be fused and even sublimed in nitrous gas without producing the slightest luminous appearance, if the gas be perfectly pure; yet if a bit of phosphorus be placed in a copper ladle, then inflamed and introduced into the gas when in a state of actual inflammation, it burns with almost as much brilliancy as in oxigen gas.

Rationale...The rationale of this experiment proves that at the heat of ignition, phosphorus is capable of disturbing the equilibrium of the affinity subsisting between oxigen and nitrogen in nitrous gas, on which account it attracts the former from the nitrous gas and leaves the latter behind.

Experiment X.

Nitrous gas inflames charcoal when introduced in a state of ignition.

If a piece of ignited charcoal be introduced into nitrous gas there will also be a vivid inflammation; this experiment may likewise be performed by setting fire to the charcoal confined in nitrous gas, by means of a burning lens.

Rationale...The charcoal at the temperature of ignition decomposes the nitrous gas, by subtracting its oxigen; hence carbonic acid is formed which may be evinced by admitting to the residuary gas, a solution of barytes, strontia, or lime in water.

Experiment XI.

Nitrous gas is absorbed by green muriate, sulphate, and nitrate of iron.

A very concentrated solution of pure green muriate of iron, (prepared by dissolving iron filings perfectly free from rust, in muriatic acid, evaporating the solution briskly, and preserving it from the contact of atmospheric air,) is extremely well calculated to ascertain the quantity of nitrogen gas contained in a given quantity of nitrous gas, in an easy manner.

To prove the absorption of nitrous gas by this means it is only necessary to agitate in a graduated tube a quantity of the gas in contact with the solution; the green solution of iron will soon assume a brown colour, the gas will be diminished, and the solution ascend into the tube.

A solution of pure green sulphate of iron (prepared by dissolving clean iron filings in sulphuric acid, and then agitating the solution in contact with sulphurated hidrogen gas) answers the same purpose. Pale green nitrate of iron may likewise be used with advantage.

Rationale...The absorption of the nitrous gas, by means of these solutions, takes place without any decomposition of it at common temperatures. It depends merely on an equilibrium of affinity produced by the following simple attractions.

1. That of green oxid of iron for the oxigen of nitrous gas and water.

2. That of the hidrogen of the water for the nitrogen of the nitrous gas; and,

3. That of the principles of the sulphuric acid for nitrogen and hidrogen.

Remark...That this is the true cause of the absorption, Professor Davy has sufficiently proved in his Researches, p. 176. Vauquelin and Humbolt have been mistaking with regard to

...ncentrated s...
...us gas. Sulph...
...ne gas absorbe...
...is also abs...
...ct with wat...
...ne at the *minim*...
...metallic solu...
...is capable of de...
...of oxidat...
...gas and water will ...
...of metallic sol...
...temperatures, as ...
...tures. Davy suppose...
...of the metallic oxid...

Experiment XII.

Nitrous gas decomposed by nascent hi...

When nitrous gas is exposed to wetted iron f...
...its volume slowly takes place: the iron ...

ning the iron filings may next be removed by withdrawing it ough the water, and the remaining gas may be made the sub- of experiment.

This decomposition of nitrous gas is more quickly effected by ting plates of iron into a solution of nitrate of copper.

RATIONALE...The water in contact with the iron is decom- ed by virtue of the affinity subsisting between its oxigen and iron. Its hidrogen with a portion of oxigen at the same e attracts the nitrogen of the nitrous gas and produces water, monia, and nitrous oxid.

REMARK...That the iron is not oxidated in this process at the ense of the oxigen of the nitrous gas, becomes obvious when consider that water is essentially necessary to produce the de- mposition; for dry iron filings effect no change whatever in rous gas at the usual temperatures.

Alcaline sulphurets moistened with water, put into a vessel ed with nitrous gas, decompose it in a short time, the remain- gas is no longer reddened by the contact of air, the greatest rt is nitrous oxid.

EXPERIMENT XIII.

Nitrous gas is decomposed by exposure to zinc and water.

When nitrous gas is exposed to a large surface of zinc in con- ct with water, it will be slowly converted into nitrous oxid; at he same time that ammonia is generated and white oxid of zinc formed, if the process is suffered to go on for a considerable ime.

RATIONALE...These phenomena depend like the former upon he decomposition of water by the affinities of part of the oxigen nd nitrous gas, for its hidrogen to form ammonia and water.

REMARK...Zinc placed in contact with water, and confined y mercury, decomposes it, as Davy observed, at common tem- eratures. But zinc when perfectly dry, does not in the slightest

its nature;* the products they obtained must have arisen from the exposure of their impregnated solution to the atmosphere.

The absorption of nitrous gas by means of these salts of iron is proportionable to the degree of the concentration of the solution.

Seventy-five cubic inches of concentrated solution of muriate of iron absorb about 18 of nitrous gas. Sulphate of iron absorbs only one half of this quantity; the gas absorbed may be expelled again by heat.

Nitrous gas (according to Davy) is also absorbed by muriate of white prussiate of iron, in contact with water; by sulphate of tin; sulphate and muriate of zinc at the *minimum* of oxidation; and probably by many other metallic solutions hitherto not tried.

In fact, whenever the metals capable of decomposing water exist in solution at their *minimum* of oxidation, the affinities exerted by them on nitrous gas and water will be such as to produce combinations; the powers of metallic solutions to combine with nitrous gas at common temperatures, as well as to decompose it at higher temperatures, Davy supposes to be proportional in the ratio of the affinity of the metallic oxids they contain for oxigen.

Experiment XII.

Decomposition of nitrous gas by nascent hidrogen gas.

When nitrous gas is exposed to wetted iron filings, a diminution of its volume slowly takes place; the iron becomes oxidated and ammonia is formed.

For performing this experiment, wetted iron filings may be exposed on a shallow dish or plate, supported by a stand, to the action of the gas contained in a broad receiver; the vessel

* Annales de Chimie tom. 88, p. 187.

maining the iron filings may next be removed by withdrawing it through the water, and the remaining gas may be made the subject of experiment.

This decomposition of nitrous gas is more quickly effected by putting plates of iron into a solution of nitrate of copper.

RATIONALE...The water in contact with the iron is decomposed by virtue of the affinity subsisting between its oxigen and the iron. Its hidrogen with a portion of oxigen at the same time attracts the nitrogen of the nitrous gas and produces water, ammonia, and nitrous oxid.

REMARK...That the iron is not oxidated in this process at the expense of the oxigen of the nitrous gas, becomes obvious when we consider that water is essentially necessary to produce the decomposition; for dry iron filings effect no change whatever in nitrous gas at the usual temperatures.

Alcaline sulphurets moistened with water, put into a vessel filled with nitrous gas, decompose it in a short time, the remaining gas is no longer reddened by the contact of air, the greatest part is nitrous oxid.

EXPERIMENT XIII.

Nitrous gas is decomposed by exposure to zinc and water.

When nitrous gas is exposed to a large surface of zinc in contact with water, it will be slowly converted into nitrous oxid; at the same time that ammonia is generated and white oxid of zinc is formed, if the process is suffered to go on for a considerable time.

RATIONALE...These phenomena depend like the former upon the decomposition of water by the affinities of part of the oxigen and nitrous gas, for its hidrogen to form ammonia and water.

REMARK...Zinc placed in contact with water, and confined by mercury, decomposes it, as Davy observed, at common temperatures. But zinc when perfectly dry, does not in the slightest

degree act upon nitrous gas. Van Marum remarked that tin, lead, iron, and mercury were all oxidated by taking the electric spark in contact with nitrous gas. Davy, who has made the greatest number of experiments concerning the nature of nitrous gas, considers the analysis of it by charcoal as affording *data* best calculated for determining the respective quantities of nitrogen and oxigen in a given bulk of nitrous gas, and correcting it by mean calculations derived from the decomposition of nitrous gas by pyrophorus and hidrogen, and its conversion into nitrous oxid, concluded that 100 grains of nitrous gas are composed of 55.95 of oxigen and 44.05 of nitrogen gas; or taking away decimals, of 56. oxigen and 44. nitrogen gas. This estimation agrees very well with the mean proportions of Priestley's experiments. But as Priestley never ascertained the absolute purity of the gas he made use of, and probably employed different kinds, in different experiments, it is impossible to fix on any one, from which accurate conclusions can be drawn.

Lavoisier's estimation of the respective quantities of oxigen and nitrogen gas, entering into the composition of nitrous gas, has been generally adopted. He supposed 64 parts of nitrous gas, to be composed of $43\frac{1}{2}$ of oxigen and $20\frac{1}{2}$ of nitrogen gas The difference between this and Davy's account is very great indeed, but Davy* has pointed out many sources of error in the experiments of this great man concerning the decomposition of nitrate of potash by charcoal, which were fundamental to his account of the composition of this gas.

* Researches chemical and philosophical, 1800, Div. I.

GAZEOUS OXID OF NITROGEN; OR NITROUS OXID.

PART XXVI.

THE combination of nitrogen and oxigen which we considered before under the name of nitrous gas does not constitute the first degree of oxigenation of nitrogen; there is another degree below this. This combination was formerly called dephlogisticated nitrous gas, but now gazeous oxid of nitrogen or nitrous oxid. It was first discovered by Priestley. Its nature and properties have since been investigated (though not very accurately) by a society of Dutch chemists.

Professor Davy has examined with uncommon accuracy the formation and properties of all the substances concerned in its production. He has detected the sources of error in the experiments of Priestley and the Dutch chemists, and to him we are indebted for a thorough knowledge of this gas. We shall therefore exhibit the philosophy of this gazeous fluid as we find it in his researches concerning the nitrous oxid.

SECT. L.

PROPERTIES

OF

GAZEOUS OXID OF NITROGEN.

GAZEOUS oxid of nitrogen exists in the form of permanent gas. A candle burns with a brilliant flame and crackling noise in it; before its extinction the white inner flame becomes surrounded with a blue one. Phosphorus introduced into it, in a state of *actual* inflammation, burns with increased splendor, as in oxigen gas. Sulphur introduced into it when burning with a feeble blue flame is instantly extinguished; but when in a state of *vivid inflammation*, it burns with a rose coloured flame. Ignited charcoal burns in it more brilliantly than in atmospheric air. Iron wire with a small piece of wood affixed to it when inflamed, and introduced into a vessel filled with this gas burns vehemently and throws out bright scintillating sparks. No combustible body however burns in it, unless it be previously brought to a state of vivid inflammation. Hence sulphur may be melted, and even sublimed in it, phosphorus may be liquified in it without undergoing combustion. Nitrous oxid is pretty rapidly absorbed by water that has been boiled; a quantity of gas equal to rather more than half the bulk of the water may be thus made to disappear, the water acquires a sweetish taste, but its other properties do not differ perceptibly from common water. The whole of the gas may be expelled again by heat. It

does not change blue vegetable colours. It has a distinctly sweet taste, and a faint, but agreeable odour. It undergoes no diminution when mingled with oxigen or nitrous gas. Most of the liquid inflammable bodies, such as ether, alcohol, volatile and fat oils, absorb it rapidly and in great quantity. Acids exert but little action on it. The affinity of the neutro-saline solutions for gazeous oxid of nitrogen is very feeble. Green muriate and green sulphate of iron whether holding nitrous gas in solution, or not, do not act upon it. None of the gases when mingled with it, suffer any perceptible change at common temperatures; the muriatic and sulphureous acid gases excepted, which undergo a slight expansion. Alcalies freed from carbonic acid exposed in the dry or solid form have no action upon it; they may however be made to combine with it in the nascent state, and then constitute *saline compounds* of a peculiar nature. These combinations deflagrate when heated with charcoal, and are decomposed by acids; the gazeous oxid of nitrogen being disengaged. It undergoes no change whatever from the simple effect of light. The action of the electric spark for a long while continued, converts it into a gas analogous to atmospheric air and nitrous acid; the same is the case when it is made to pass through an ignited earthern tube. It explodes with hidrogen in a variety of proportions, at very high temperatures; for instance, when electric sparks are made to pass through the mixture. Sulphurated, heavy and light carbonated hidrogen gases, and gazeous oxid of carbon likewise burn with it when a strong red heat is applied. 100 parts by weight of nitrous oxid, contain 36.7 of oxigen and 63.3 of nitrogen; 100 cubic inches weigh 50 grains at 55° temperature and 30 atmospheric pressure. Animals when wholly confined in gazeous oxid of nitrogen, give no signs of uneasiness for some moments, but they soon become restless and then die. When gazeous oxid of nitrogen is mingled with atmospheric air, and then received into the lungs, it generates highly pleasurable sensations; the effects it produces on the animal system are eminently distinguished from every other chemi-

cal agent. It excites every fibre to action, and rouses the faculties of the mind, inducing a state of great exhilaration, an irresistible propensity to laughter, a rapid flow of vivid ideas, and unusual vigour and fitness for muscular exertions, in some respects resembling those attendant on the pleasantest period of intoxication, without any subsequent languor, depression of nervous energy, or disagreeable feelings; but more generally followed by vigour, and a pleasurable disposition to exertion, which gradually subsides.

Such are the properties which characterize the nitrous oxid.

The Dutch chemists and some French and German philosophers assert* that it cannot be respired; that burning phosphorus, sulphur, and charcoal are extinguished in it, &c. It is probable they did not examine it in a state of purity, for it is otherwise difficult to account for these and many other erroneous opinions.

METHODS OF OBTAINING GAZEOUS OXID OF NITROGEN.

Gazeous oxid of nitrogen is produced, when substances having a strong affinity with oxigen are brought into contact with nitric acid, or with nitrous gas. It may therefore be obtained by various processes, in which nitrous gas or nitric acid is decomposed by substances capable of attracting the greater part of their oxigen. The most commodious and expeditious, as well as cheapest mode of obtaining it, is by decomposing nitrate of ammonia, *at a certain temperature,* in the following manner.

1. Introduce into a glass retort some pure nitrate of ammonia, and apply the heat of an Argand's lamp; the salt will soon liquify, and when it begins to boil, gas will be evolved. Increase the heat gradually till the body and neck of the retort become

* Gren's Principles of Chemistry, 1800.
Scherer's Introduction to the Knowledge of Gazeous Bodies, 1801.

filled with a semi-transparent milky-white vapour. In this state the temperature of the fused nitrate is between 340° and 480°. After the decomposition has proceeded for a few minutes, so that the gas evolved quickly enlarges the flame of a taper held near the orifice of the retort, it may be collected over water, care being taken during the whole process, never to suffer the temperature of the fused nitrate to rise above 500° Fahr. which may easily be judged of, from the density of the vapours in the retort, and from the quiet ebullition of the fused nitrate; for if the heat be increased beyond this point, the vapours in the retort acquire a reddish and more transparent appearance; and the fused nitrate begins to rise, and occupy twice the bulk it did before. The nitrous oxid, after its generation, is allowed to stand over water, for at least six hours, and is then fit for respiration or other experiments.

Rationale...Nitrate of ammonia consists of nitric acid and ammonia; nitric acid is composed of nitrous gas and oxigen; and ammonia consists of hidrogen and nitrogen. At a temperature of about 480° the attractions of hidrogen for nitrogen in ammonia, and that of nitrous gas for oxigen in nitric acid, are *diminished*; while on the contrary, the attractions of the hidrogen of ammonia for the oxigen of the nitric acid, and that of the remaining nitrogen of the ammonia for the nitrous gas of the nitric acid, are *increased*; hence all the former affinities are broken, and new ones produced, namely; the hidrogen of the ammonia attracts the oxigen of the nitric acid, the result of which is *water*; the nitrogen of the ammonia combines with the liberated nitrous gas, and forms *nitrous oxid*. The water and nitrous oxid produced, probably exist in binary combination in the aeriform state, at the temperature of the decomposition.

Such is the philosophy of the production of gazeous oxid of nitrogen, by decomposing nitrate of ammonia at that temperature, given by Davy.

To illustrate this complicated play of affinity more fully, the following sketch may not be deemed superfluous.

DIAGRAM,

EXHIBITING

THE PRODUCTION

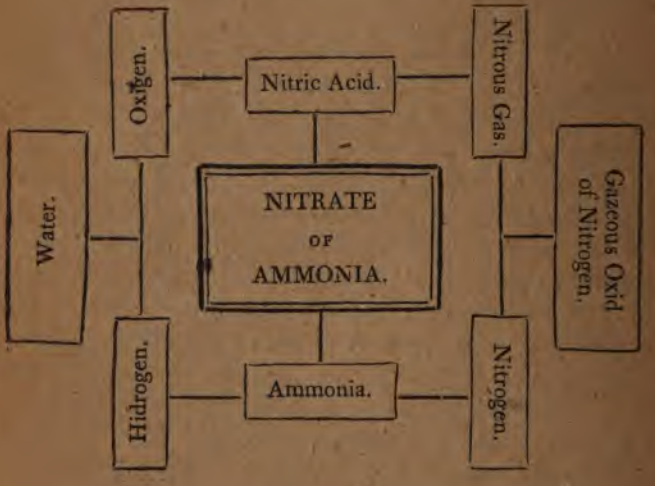
OF

GAZEOUS OXID OF NITROGEN,

BY DECOMPOSING

NITRATE OF AMMONIA,

AT 480° FAHR.



REMARK...Professor Davy has likewise pointed out that when the heat employed for decomposing nitrate of ammonia is raised above the before-stated temperature another play of affinities takes place; the attractions of nitrogen and hidrogen for each

other and of oxigen for nitrous gas are still more diminished, whilst that of nitrogen for nitrous gas is totally destroyed, and that of hidrogen for oxigen increased to a greater extent. A new attraction likewise takes place, namely, that of nitrous gas for nitric acid to form *nitrous vapour*,* and a new arrangement of principles is rapidly produced: the nitrogen of the ammonia having no affinity for any of the single principles at this temperature, enters into no binary compound; the oxigen of the nitric acid forms water with the hidrogen, and the nitrous gas combines with the nitric acid to form *nitrous vapour*.

All these substances most probably exist in combination, at the temperature of their production; and at a lower temperature assume the form of *nitrous acid*, *nitrous gas*, *nitrogen*, and *water*; and hence we see the necessity of not heating the nitrate of ammonia above the before-stated temperature.

On account of the rapid absorption of gazeous oxid of nitrogen by water, it is economical to preserve the fluid which has been used to confine this gas, and to make use of it for collecting other quantities of it. In order to hasten its production, the nitrate of ammonia may be previously freed from its water of crystallization by gently fusing it in a glass or Wedgwood's bason for a few minutes, and then keeping it for use in a well-stopped bottle.

2. Nitrous oxid may likewise be obtained by exposing common nitrous gas to alcaline sulphites, particularly to sulphite of potash containing its full quantity of water of crystallization. The nitrous oxid produced from nitrous gas by sulphite of potash has all the properties of that generated from the decomposition of nitrate of ammonia.

RATIONALE...The conversion of nitrous gas into nitrous oxid, by these bodies, depends on the abstraction of a portion of its oxigen by the greater affinity of the sulphite presented to it.

* Hence the reddish vapour in the retort, stated before, page 295.

The nitrogen and remaining oxigen assume a more condensed state of existence, and constitute nitrous oxid.

3. Nitrous oxid may also be obtained by mingling together nitrous gas and sulphurated hidrogen gas. The volume of gases in this case is diminished, sulphur deposited, ammonia, water, and nitrous oxid are formed.

RATIONALE...The change of principles which takes place in this experiment depends upon the combination of the hidrogen of the sulphurated hidrogen gas, with different portions of the oxigen and nitrogen of the nitrous gas, to form water and ammonia, and to deposit sulphur. The remaining oxigen and nitrogen being left in due proportion constitute nitrous oxid.

REMARK...This singular exertion of attractions by a simple body appears highly improbable *a priori*; but the formation of ammonia, and the non-oxigenation of the sulphur, elucidate the fact. In performing this experiment care should be taken that the gases should be rendered as dry as possible; for the presence of water considerably retards the decomposition.

4. Nitrous oxid may also be produced by presenting alcaline sulphurets to nitrous gas. Davy observed that a solution of sulphuret of strontia, or barytes, answers this purpose best.

RATIONALE...This decomposition of nitrous gas is not solely produced by the abstraction of oxigen from the nitrous gas, to form sulphuric acid. It depends equally on the decomposition of the sulphurated hidrogen dissolved in the solution or liberated from it. In this process, sulphur is deposited and sulphuric acid formed.

5. Nitrous oxid is obtained in many circumstances similar to those in which Nitrous gas is produced. Dr. Priestley found that nitrous oxid was evolved, together with nitrous gas, during the solution of iron, tin, and zinc in nitric acid.

RATIONALE...It is difficult to ascertain the exact rationale of these processes, for very complicated agencies of affinities take place. Either the nascent hidrogen arising from the decomposition of the water by the metallic substance may combine

with portions of the oxigen and nitrogen of the nitrous gas; and thus by forming water and ammonia, convert it into nitrous oxid; or the metallic substance may attract at the same time oxigen from the water and nitrous gas, whilst the nascent hidrogen of the water seizes upon a portion of the nitrogen of the nitrous gas, to form ammonia. The analogy between this process and the decomposition of nitrous gas by sulphurated hidrogen render the first opinion most probable.

Such are the principal methods of obtaining nitrous oxid. There are no reasons, Davy thinks, for supposing that nitrous oxid is formed in any of the processes of nature, and the nice equilibrium of affinity by which it is constituted forbids us to hope for the power of composing it from its simple principles. We must be content to produce it artificially.

SECT. II.

EXPERIMENTAL PROOFS OF THE PROPERTIES OF GAZEOUS OXID OF NITROGEN.

Experiment I.

Gazeous oxid of nitrogen is rapidly absorbed by water.

FILL a glass cylinder or graduated tube with water previously boiled, and invert it in a bason of the same fluid. Having done this send up into it a quantity of nitrous oxid, and mark the level of the water in the cylinder. Then agitate it for a few minutes in the water, and the bulk of the gas will be seen considerably diminishing. Water may thus be made to absorb about one half of its own bulk of gazeous oxid of nitrogen.

On boiling the water, the gas which was absorbed will be liberated, possessing all its former properties.

If nitrous oxid be repeatedly exposed to water, the residual gas will be the common air previously contained in the water and from which it can in no case be perfectly freed by ebullition; this air becomes separated on account of the greater affinity of water for nitrous oxid. The quantity of common air thus produced generally amounts to about $\frac{1}{16}$ part of the volume of water.

The absorption of nitrous oxid by the inflammable fluids enumerated before may be evinced in a similar manner.

Experiment II.

Combustible bodies do not burn in gazeous oxid of nitrogen, except when in a state of actual inflammation.

Fill a jar over mercury with gazeous oxid of nitrogen, and keep it over that fluid; introduce into it a small piece of sulphur, camphor, or phosphorus, and touch these substances with a bent wire heated to a *dull redness*. The sulphur, camphor, or phosphorus will melt, and on continuing the heat may even be made to sublime in the gas, but no accension will take place.

But that the gas is capable of maintaining the combustion of inflammable substances becomes evident from the following facts:

Experiment III.

Combustion of the taper in gazeous oxid of nitrogen.

Immerse a lighted taper into a jar filled with nitrous oxid. The flame of the taper will become instantly larger, it will first burn with a brilliant white flame and sparkle as in oxigen gas. As the combustion goes on, the lustre of the flame diminishes; it gradually lengthens and becomes surrounded with a pale blue cone of light, from the apex of which much unburnt charcoal is thrown off in the form of smoke. The flame continues double to the end of the process.

Experiment IV.

Combustion of phosphorus in gazeous oxid of nitrogen.

Put a piece of phosphorus of the size of a pea into a copper ladle, set fire to the phosphorus with a match, and quickly intro-

duce it into a jar filled with the gas. The phosphorus will continue to burn with a splendor nearly equal to that in oxigen gas.

The accension of phosphorus may likewise be evinced in the following manner:

Experiment V.

Fill a strong glass cylinder over mercury, one-eighth full of gazeous oxid of nitrogen; send up into it a few grains of phosphorus, heat a bent iron wire *white-hot,* and introduce it quickly through the mercury to touch the phosphorus, which thus will take fire instantly with a considerable detonation.

Remark...This experiment requires caution, the cylinder in which the phosphorus is inflamed should be very strong. The gazeous oxid employed should not exceed one-eighth of the capacity of the jar. The wire for the inflammation ought to be very well curved so as to be expeditiously introduced into the jar and capable of being quickly withdrawn. We have witnessed several accidents where the detonating jar burst during this experiment.

Another very successful method is as follows:

Experiment VI.

Let the jar containing the gazeous oxid of nitrogen be placed over mercury; introduce the phosphorus in a small tube containing oxigen gas, so balanced as to swim on the surface of the mercury without communicating with the gazeous oxid. The phosphorus is then fired in the oxigen gas, with an ignited iron wire, by which at the moment of combustion, the tube containing it must be raised into the gazeous oxid, and thus the combustion continues.

Experiment VII.

Sulphur burning with a feeble blue flame, becomes instantly extinguished in gazeous oxid of nitrogen.

Put a piece of sulphur into a copper ladle, set fire to it, by means of a candle, and when it begins to burn with a blue feeble flame introduce it into a jar filled with gazeous oxid of nitrogen. The sulphur will be extinguished the instant it is plunged into the gas.

But that sulphur may be made to burn in it, becomes obvious from the following

Experiment VIII.

Sulphur in a state of vivid inflammation burns with a rose-coloured flame in gazeous oxid of nitrogen.

Dip a slip of copper into melted sulphur; when cold set fire to it, and when in an actual state of combustion introduce it into a jar filled with the gas, it will continue burning with a beautiful flame very much enlarged and of a vivid rose-colour.

This experiment may be more accurately performed in the same manner as the inflammation of phosphorus; namely, by introducing it into the small vessel filled with oxigen gas and igniting it by means of the heated wire.

Experiment IX.

Detonation of gazeous oxid of nitrogen with carbonated hidrogen gas.

Nitrous oxid and carbonated hidrogen gas possess no action on each other, except at high temperatures. But when mingled to-

gether in certain proportions and exposed to the electric spark, a new arrangement of their principles takes place. This may be proved in the following manner:

Mingle together in a detonating tube, 35 parts of gazeous oxid of nitrogen and 15 of carbonated hidrogen gas. On passing the electric spark through it, the inflammation will be very vivid, and the light produced, bright red. After the explosion the space occupied by the gases will be about 60.

When 22 parts of nitrous oxid and 20 of hidro-carbonate are exploded, the residue fills a space equal to 45.

If strontia water be brought into contact with the gas after the detonation, a white precipitate is instantly formed and a diminution takes place. On presenting nitrous gas to this residue, the gas again becomes diminished.

RATIONALE...Reasoning from analogy there can be little doubt, but that when carbonated hidrogen gas is inflamed with excess of gazeous oxid of nitrogen, it will be only partially decomposed or converted into nitrogen, nitrous acid, and atmospheric air.

EXPERIMENT X.

Gazeous oxid of nitrogen and phosphorated hidrogen gas, detonate likewise.

Phosphorated hidrogen gas and gazeous oxid of nitrogen exert no action upon each other at common temperatures, but that they may be made to act upon each other at a very high temperature, the following experiments will prove.

1. Mix 10 grain measures of phosphorated hidrogen gas and 52 of gazeous oxid of nitrogen, in a graduated detonating tube, and pass the electric spark through it. A very vivid inflammation will take place, and the tube will be filled with white vapour. The volume of the gas left behind will fill a space nearly equal

to 60. On agitating this fluid in contact with water no absorption will take place. On admitting nitrous gas a diminution ensues.

Rationale...It appears from this experiment that when a small quantity of phosphorated hidrogen gas is inflamed with gazeous oxid of nitrogen, both the phosphorus and hidrogen are consumed; whilst the super-abundant gazeous oxid, is converted into nitrous acid, and atmospheric air, by the ignition; or a certain quantity is partially decomposed into atmospheric air by the combination of a portion of its oxigen with the combustible gas.

2. Twenty-five parts of gazeous oxid of nitrogen mingled with 10 of phosphorated hidrogen gas, may likewise be inflamed. After the detonation white dense vapours become visible, and the gas left occupies a space equal to 25. The residuary gas is not absorbable by water; on admitting a solution of green sulphate of iron, or prussiate of potash, no blue or green precipitate is produced, but if 25 parts of nitrous gas are mingled with it, the result will be 50.

Rationale...From this experiment we learn that when phosphorated hidrogen gas and gazeous oxid are to each other as 25 to 10, they both disappear, whilst nitrogen is evolved, and water and phosphoric acid produced. Reasoning concerning the composition of gazeous oxid of nitrogen from this result, we should conclude that it was composed of about 38 oxigen and 62 nitrogen.

3. Ten grain-measures of gazeous oxid, mingled with 20 of phosphorated hidrogen gas cannot be inflamed.

4. Twenty-five of gazeous oxid of nitrogen with 20 of phosphorated hidrogen gas inflame readily. The gas after detonation is likewise opaque, and fills a space equal to about 45. The residue is not miscible with water, no white fumes are produced by admitting oxigen gas.

Rationale...Here we are taught that the affinity of phosphorus for the oxigen of gazeous oxid of nitrogen, is stronger than

hus be made to burn with a beautiful white flame surrounded
green one, and dense white vapours of oxid of zinc will fill
ceiver.

Experiment XIV.

Accension of pyrophorus in gazeous oxid of nitrogen.

ophorus, which readily inflames in nitrous gas (as we have
efore, experiment VIII. p. 285,) and in atmospheric air at
temperature, requires for its combustion in nitrous oxid, a
greater degree of heat. It will not burn in it even at 212°.
er to inflame pyrophorus in gazeous oxid of nitrogen over
ry, the wire must be strongly heated, but not ignited. The
horus then takes fire, and burns with a splendid white
greatly resembling that produced in oxigen gas.

INFERENCES.

m the preceding experiments it becomes evident that the
mable bodies in general require for their combustion in
is oxid of nitrogen, much higher temperatures than those
ch they burn in oxigen gas or atmospheric air. When in-
heated, they decompose it with the production of much
id light, and become oxigenated. During the combustion
d or fluid bodies producing flame in it, nitric acid is gene-
and that probably from a new arrangement of principles
ous to those stated before. Likewise when gazeous oxid
rogen in excess is decomposed by inflammable gases, ni-
cid, and sometimes a gas analogous to common air is pro-
doubtless from the same cause.

phorus is the only body that inflames in gazeous oxid of
n below the temperature of ignition.

sphorus burns in it with a blue flame, probably forming
only phosphorous acid a little above a dull red heat; but
heated more intensely, phosphoric acid is produced.

AMMONIA,

OR

AMMONIACAL GAS.

PART XXVII.

SECT. I.

THIS gas was first discovered by Dr. Priestley. It is composed of hidrogen and nitrogen rendered gazeous by the addition of caloric.

PROPERTIES OF AMMONIA.

Ammonia gas has a strong and very pungent odour. It extinguishes flame, yet it increases the magnitude of the flame of a taper before extinction, producing a pale yellow colour round its edge. Animals cannot breathe it without death ensuing. It is lighter than atmospheric air, in the proportion of three to five. It tinges yellow vegetable colours brown, and blue ones green. It is rapidly absorbed by cold water; by ardent spirit, essential oils, ether, charcoal, sponge, bits of linen cloth, and all porous bodies.

When a piece of ice is brought in contact with this gas, it melts and absorbs the gas, while at the same time its temperature is diminished. It has no effect upon oxigen gas while cold; but when made to pass with it through an ignited tube, it detonates and becomes decomposed. The same is the case with common air. It is also decomposed by phosphorus at high temperatures.

It does not explode when mixed with hidrogen gas. Nitrogen gas has no effect upon it. Atmospheric air does not combine with it at common temperatures, but only mixes with and dilutes it. When made to pass through ignited charcoal it forms with it a substance called prussic acid. If brought into contact with acid gases, both gases lose their gazeous form and become concrete. It has no sensible action on earths or on the *salino-terrene* substances. It combines readily with acids, and unites to sulphur when both are in a state of vapour. It reduces oxids of metals to their metallic state, and is decomposed by them. It is also decomposed by electrization and by oxigenated muriatic acid gas, &c. When exposed to the temperature of — 46° it crystallizes, and when suddenly cooled down to — 68° it assumes a gelatinous appearance, and has scarcely any odour.*

METHODS OF OBTAINING AMMONIA.

1. Mix together equal quantities of muriate of ammonia and quick-lime, separately powdered; introduce them into a gas-bottle or retort, apply the heat of a lamp, and receive the gas over mercury.

RATIONALE...Muriate of ammonia consists of muriatic acid and ammonia; on adding lime to it a decomposition takes place, the muriatic acid quits the ammonia and unites to the lime, in order to form muriate of lime which remains in the retort, and the ammonia flies off in the state of gas.

* Fourcroy and Vauquelin, *Ann. de Chim.* XXIX. p. 289.

Remark...In order to obtain the gas in a state of purity, it is essentially necessary that a considerable quantity of the gas first disengaged, be suffered to escape, on account of the common air contained in the distilling vessel, and in the interstices of the ingredients.

2. Ammonia may likewise be obtained by heating the liquid ammonia of the shops (water of pure ammonia, *Pharm. Lond.*) in a retort placed in communication with the mercurial pneumatic trough.

Rationale...The ammonia contained in this liquid combines with caloric, assumes the form of ammoniacal gas, and parts with the water to which it was united.

Remark...The temperature of the fluid must not be carried so high as to cause the water to be converted into vapour, or, if this cannot well be avoided, a small vessel should be interposed between the retort and the receiver which when kept cool may serve to condense the aqueous vapour which is formed and cause the ammoniacal gas to pass in a very pure and dry state.

Ammonia is likewise produced during the spontaneous decomposition of animal and vegetable substances; in these cases it did not pre-exist in them ready formed, but is generated by the union of the hidrogen and nitrogen contained in them.

receiver, and exposing it to the action of the gas. The first will soon become brown and the latter green.

The same effect may be produced by holding the papers over a bottle filled with water impregnated with ammonia.

Experiment VI.

Carbonic acid gas and ammonia, readily unite and form carbonate of ammonia.

Fill a vessel with carbonic acid gas over mercury, and add ammonia; a white vapour will instantly be formed, heat becomes evolved, the gases disappear, and carbonate of ammonia crystallizes on the inside of the vessel.

Experiment VII.

Ammonia becomes decomposed by oxigenated muriatic acid gas, at common temperatures.

Mix in a receiver over mercury two parts of oxigenated muriatic acid gas with one part by measure of ammonia. When these two bodies come in contact, a brisk detonation is produced accompanied with a yellowish light; the two gases decrease in volume, and there is formed a portion of solid matter (muriate of ammonia) which adheres to the sides of the vessel. The gas which remains has no odour like ammonia, nor colour like muriatic acid gas. It is not dissolved in water, nor does it maintain combustion; it is therefore nitrogen gas. In the bottom of the vessel there is found a clear and transparent liquid, which is water holding a certain quantity of the muriate of ammonia in solution.

Rationale...Ammonia consists of nitrogen and hidrogen dissolved in caloric. Oxigenated muriatic acid gas consists of muriatic acid, oxigen and caloric. On bringing these two gases into contact a reciprocal decomposition takes place. The oxigen of

the oxigenated muriatic acid gas combines with the hidrogen of the ammonia and forms water; while the nitrogen, the other component part of the ammonia, becomes disengaged. The oxigenated muriatic acid gas having lost its oxigen becomes converted into simple muriatic acid gas, part of it unites to part of the ammonia, (which in this experiment is present in too large a quantity to be wholly decomposed) and forms with it muriate of ammonia. The explosion, heat, and light originate from the liberated caloric which kept the gases in their aeriform state.

Remark...If a smaller portion of ammonia is added to the above quantity of oxigenated muriatic acid gas, its decomposition will be complete, and no muriate of ammonia be produced. The results then are only *muriatic acid* and *water*.

The same facts may be shown in the following manner:

Experiment VIII.

Fill four-fifths of a long glass tube with strong oxigenated muriatic acid, and the remaining fifth with water strongly impregnated with ammonia, and invert it in a saucer of water. The ammonia on account of its lightness will pass through the oxigenated muriatic acid, but by thus passing a strong effervescence is produced, the elastic fluid by which it is occasioned collects itself in the upper part of the tube, and a portion diffuses itself in the vessel. The gas disengaged will be found to be nitrogen gas.

Rationale...The explanation of this experiment is analogous to the former.

Experiment IX.

Decomposition of ammonia by means of black oxid of manganese at a high temperature.

If ammonia be made to pass over pounded black oxid of manganese brought to a red heat in a Wedgwood's tube, connected, by

means of another tube, with an empty bottle immersed in cold water or ice, abundance of red vapours will soon be produced, and these will be succeeded by white ones, condensing in the bottle into a bright transparent fluid, which has a pungent saline odour. If this liquid be distilled to dryness by a gentle heat the product will be water. The residue in the retort is of a white colour. It fuses in the fire, detonates on ignited coals; and produces vapours of nitric acid by the affusion of sulphuric acid; or ammonia when saturated with lime. It is therefore nitrate of ammonia. The black oxid of manganese has changed its colour; being turned to a pale brown, and no longer gives oxigen gas by the addition of heat.

RATIONALE...In this experiment the hidrogen of the ammonia unites to part of the oxigen given out by the black oxid of manganese and forms water. The nitrogen of the ammonia unites to another part of the oxigen and produces nitric acid, this joins to a quantity of undecomposed ammonia and forms nitrate of ammonia.

EXPERIMENT X.

Decomposition of ammonia by electrization.

For this purpose take a detonating tube, admit into it about a cubic inch of ammonia, and pass through it a succession of electric discharges. When about 200 strong shocks have traversed the gas it will have increased to three times its original bulk. On admitting a small quantity of water the gas will not as before be completely absorbed by this fluid, but a part will remain. Hence it appears that the gas has undergone a decomposition, and on examination it will be found that the chemical union of the hidrogen and nitrogen has been broken, and that that they are only mechanically mixed.

SULPHUREOUS ACID GAS.

PART XXVIII.

SEVERAL philosophers have paid attention to the properties of this gas and its combinations; but Berthollet was the first who published an accurate account of it, which Fourcroy and Vauquelin, have lately investigated still more completely. Their paper (of which we have made use) is inserted in the *Annales de Chimie*, II. 54, and copied into *Nicholson's Journal*, *vol.* I. p. 313.

We have seen before, p. 189, that when sulphur is united to oxigen it forms an acid. When the quantity of oxigen is sufficient to oxigenate a given quantity of sulphur completely, the result is a perfect acid called sulphuric acid. We shall now see that if a less quantity of oxigen is made use of, the result is an imperfect acid, capable of taking the gazeous state. To this gazeous fluid we give the name of sulphureous acid gas. It becomes obvious from this, that sulphureous acid gas, has the same relation to sulphuric acid, as phosphorous acid has to the phosphoric acid. At least this gas occupies the middle place between sulphur and sulphuric acid, which will be more evident when we shall speak of the formation of acids.

the two gases combine and sulphuric acid is formed. When passed into water cooled down to the freezing point, the union is very rapid. Water cooled to 40 degrees absorbs one third part of its weight of sulphureous acid gas. It speedily melts ice. Water saturated with it may be frozen without parting with its gas; but when water which has been saturated with it, is exposed to heat, it is filled with a vast number of bubbles which continually increase and rise to the surface; these bubbles are the gas separating from it. It is absorbed by oil, ether, and sulphuric acid, the latter when saturated with it acquires the property of smoking when exposed to air; its colour is altered to a yellowish brown, and its odour is penetrating like that of the gas. When the acid thus saturated with the gas is exposed a few degrees below the freezing point, it congeals or freezes into a crystalline mass. The same happens when submitted to distillation. It decomposes nitric and oxigenated muriatic acid, and dissolves camphor. Sulphureous acid gas and hidrogen gas have no action upon each other at common temperatures, but if they are passed through an ignited tube, a decomposition is effected. Charcoal likewise decomposes sulphureous acid gas at a high temperature. Monge and Clouet affirm that by extreme artificial cold and a strong pressure exerted at the same time, they rendered sulphureous acid gas fluid.

METHODS OF OBTAINING SULPHUREOUS ACID GAS.

1. Take one part of mercury and four of concentrated sulphuric acid; put them into a glass retort connected with the pneumatic quicksilver-trough and apply the heat of a lamp to the mixture till it boils. On continuing the heat after the mercury has been acted upon, sulphureous acid gas will be obtained in abundance.

RATIONALE...In this case a partial decomposition of the sulphuric acid takes place. The mercury abstracts part of its oxigen



SECT. II.

EXPERIMENTAL PROOFS

OF

THE PROPERTIES OF SULPHUREOUS ACID GAS.

Experiment I.

Sulphureous acid gas is heavier than atmospheric air; and will not maintain combustion.

THIS may be shown by dipping a lighted candle many times successively into a jar filled with this gas. The candle will be extinguished every time, though the jar filled with it, continues exposed to the air.

Experiment II.

Sulphureous acid gas is rapidly absorbed by water.

Fill a cylinder with the gas over mercury, and send up into it a little water. The gas will instantly become diminished, and the mercury will rise up in the vessel.

The absorption of this gas may likewise be shown by dipping the neck of the retort, in which it is disengaged, into a bason of cold water.

Remark...The combination of sulphureous acid gas with water cooled artificially, takes place with such rapidity that not a



mit a mixture of three parts of hidrogen gas and one of sulphureous acid gas, through a Wedgwood's tube in a state of ignition, sulphurated hidrogen gas will be evolved, and sulphur deposited at the extremity of the tube, opposite to that through which the gas is made to pass.

RATIONALE...Part of the hidrogen at such a temperature unites to the oxigen of the sulphureous acid gas to form water, the sulphur is consequently left uncombined; another part (or at least the excess) of the hidrogen dissolves a portion of the sulphur and becomes converted into sulphurated hidrogen gas.

REMARK...The two last experiments are well calculated to demonstrate the nature of sulphureous acid gas. In the first, it became changed into sulphuric acid by the addition of oxigen at a high temperature. In the other, hidrogen gas decomposes the sulphureous acid gas, at the same temperature, by taking from it that portion of oxigen which kept it acid, and the sulphur is disengaged.

EXPERIMENT VII.

Formation of sulphate of ammonia by mingling sulphureous acid gas and ammoniacal gas.

Let sulphureous acid gas be mixed with ammoniacal gas over mercury, a beautiful white cloud will be formed by their combination, heat is liberated and both gases gradually assume the solid state, forming sulphate of ammonia. If the gases have been pure the mercury rises almost to the top of the vessel.

If the sulphureous acid gas be presented to the ammoniacal gas the cloud is formed at the bottom, and gradually rises to the top; but if the ammoniacal gas be poured in last, the cloud rises immediately to the top. These consequences naturally result from the ammoniacal gas being the lightest.

RATIONALE...The white cloud formed in this experiment is sulphate of ammonia, which originates from the strong attraction

these gases have for each other. The caloric which kept the
in the gazeous state being set free produces the heat evolved dur
ing this union.

Experiment VIII.

Sulphuric acid saturated with sulphureous acid gas acquires a concrete form.

When sulphureous acid gas is made to pass into sulphuric acid cooled by a frigorific mixture, the gas is for a considerable time absorbed by the acid, which at last acquires a solid form. The solid acid has no very perceptible odour. If part of it be laid upon a plate of glass it exhibits an effervesence like that occasioned by the decomposition of carbonate of lime by the affusion of a weak acid. It soon afterwards becomes liquid and very odorous.

Remark...We have therefore a concrete sulphuric acid formed by the addition of sulphureous acid gas. Nitrous gas is also said to possess the same property. There is no doubt but that other concrete modifications occasioned by other gases will be discovered hereafter.

Experiment IX.

Decomposition of sulphureous acid gas by charcoal.

When sulphureous acid gas is passed through a tube containing ignited charcoal, carbonic acid gas and sulphurated hidrogen gas are obtained, and the inner surface of the tube is lined with sulphur.

Rationale...The charcoal at the temperature of ignition takes the oxigen from the sulphureous acid gas and forms with it

carbonic acid gas; the sulphur therefore becomes precipitated. The sulphurated hidrogen gas arises from a portion of water contained in the charcoal.

Experiment X.

Decomposition of sulphureous acid gas by muriate of tin.

Fill a cylinder with sulphureous acid gas, and pass up into it some *fresh prepared* concentrated muriate of tin, the volume of the gas will soon become diminished and sulphur be deposited.

Rationale...The muriated oxid of tin robs the sulphureous acid gas of its oxigen, and becomes converted into oxigenated muriate of tin, and the sulphur deprived of its oxigen is deposited.

MURIATIC ACID GAS.

PART XXIX.

SECT. I.

THE basis of this gas is still unknown. The presence of oxigen has not been even demonstrated in it, and it is only by analogy that we may venture to suppose it instrumental in this acid gas.

PROPERTIES OF MURIATIC ACID GAS.

Muriatic acid gas has a very pungent and suffocating odour, which excites coughing. It is readily absorbed by water, by ardent spirit, ether, fat and essential oils, melted wax, phosphorus, and many other bodies. It is a true acid. It suffocates animals, and is so very caustic as to excoriate the skin. It extinguishes a lighted taper, the flame of which becomes green, or rather light blue, at the upper part of its disk. Light has no effect upon it. Caloric rarefies it. It is heavier than common air. The specific gravity of the former is to that of the latter as

1.750 to 1.000. When brought into contact with atmospheric air, or oxigen gas, it forms a white cloud. Ice is melted by it as speedily as if thrown into the fire. It unites to alcaline and terrene substances, and forms with them new compounds. It has no action on siliceous earths. It combines with alumine and magnesia. It absorbs oxigen, when in the state of gas, feebly, though there are methods of uniting them readily. If ammoniacal gas be mixed with it and heat applied, both gases lose their gazeous form in a moment, and are transformed to a concrete salt. Carbonic acid gas, nitrogen gas, gazeous oxid of nitrogen, sulphurated hidrogen gas, and carbonated hidrogen gas have no action upon it. It has never been found in a disengaged state in nature. When electric explosions are made to pass through it, its bulk is diminished and hidrogen gas is evolved. These changes are owing to a quantity of water contained in the gas, and cease when it is deprived of moisture, as has been proved by Mr. Henry*

METHODS OF OBTAINING MURIATIC ACID GAS.

1. Muriatic acid gas may be obtained by decomposing muriate of soda by means of sulphuric acid. For this purpose, put into a tubulated retort two parts of very dry muriate of soda and pour on it gradually one part of concentrated sulphuric acid. A violent action takes place and muriatic acid gas becomes liberated, which must be collected over mercury in the usual manner.

RATIONALE...The sulphuric acid has a greater affinity for the soda, than the muriatic acid has, it therefore unites to it and forms sulphate of soda. The muriatic acid being liberated, takes the gazeous form, and appears as muriatic acid gas.

REMARK...As this decomposition takes place very rapidly, it is not necessary to apply heat, until the disengagement of the

* Nicholson's Journal, vol. IV. p. 209.

gas begins to slacken, after which the further extrication may be assisted by the heat of a lamp.

2. Muriatic acid gas may likewise be obtained by expelling it from its combination with water.

For this purpose put concentrated muriatic acid into a retort, immerse the beak of it under a receiver placed in a mercurial pneumatic trough, and filled with that metal. On exposing the acid to a gentle heat muriatic acid gas will be obtained. If the process be very carefully managed nothing but water remains in the retort.

3. Muriatic acid gas is likewise produced by putting any quantity of liquid muriatic acid into a long glass tube, and adding to it about one-third or one-fourth by measure of concentrated sulphuric acid. A violent effervescence takes place, and the whole tube becomes filled with dense white vapours, which are muriatic acid gas, condensed again by means of the moisture in the atmosphere. The sulphuric acid added to the muriatic acid deprives the latter of part of its water, a combination and penetration of the two liquids take place, and caloric is evolved, contributing to render the gas aeriform, which is thus forced to escape.

This experiment proves that the affinity of sulphuric acid for water is greater than that of muriatic acid.

SECT. II.

EXPERIMENTAL PROOFS

OF THE

PROPERTIES OF MURIATIC ACID GAS.

Experiment I.

Muriatic acid gas is readily absorbed by water.

FILL a receiver with muriatic acid gas, and introduce into it a little water, the gas will speedily be absorbed, and the fluid exhibit all the properties of muriatic acid.

The absorption may also be shown by disengaging the gas in a retort and dipping the neck into a bason of water, or letting it pass into a receiver moistened with a small quantity of this fluid.

Remark...Water when charged as highly as possible with this gas forms the ordinary muriatic acid in a liquid state. Ten grains of water are capable of absorbing 10 grains of the gas. The solution thus obtained occupies the space of 13.3 of water nearly. Water heated absorbs it with difficulty. The colder the water the more it absorbs.

Experiment II.

Muriatic acid gas melts ice speedily.

This experiment may be shown by passing the current of muriatic acid gas as it is disengaged, into a vessel filled with ice broken into small pieces. The ice will melt as rapidly as if heat were applied.

Rationale...The rapid liquefaction depends on the vast quantity of caloric which is evolved by the gas when returning from the gazeous to the liquid state, which becomes absorbed by the ice and melts it.

Experiment III.

Muriatic acid gas when brought into contact with air forms white clouds.

If a wide-mouthed bottle be half filled with muriatic acid gas, and atmospheric air be admitted, by removing it from the mercury over which it was charged, the whole vessel will be instantly filled with dense white vapours, and a slight degree of heat will be produced.

Rationale...The vapours are occasioned by the moisture in the air, to which the muriatic acid gas unites in order to become converted into liquid muriatic acid, abandoning at the same time its combined caloric, which becoming free produces the heat.

Remark...The more humid the air the denser the vapours are on presenting muriatic acid gas to it, and for that reason they are never produced on the summits of mountains or other places where the air is very dry.

This production of white vapour is therefore a sure sign of the humidity of the air.

If muriatic acid gas and ammonia be min
cylinder over mercury, the mixture become
and a white cloud is formed. The mercury ri
ammonia will be formed, which crystallizes
face of the receiver, during the subsiding of
If the two gases are very pure and perfectly dr
disappear and the disengagement of caloric is

RATIONALE...The production of the muri
owing to the attraction of the bases of the
other being greater than that of the caloric w
the gazeous state: they therefore abandon the
form a solid combination called muriate of am

EXPERIMENT V.

*Muriatic acid gas extinguishes the flame of bu
enlarging it by the addition of a green or bl
flame.*

If a lighted taper be let down into a receiver
acid gas the flame will be extinguished; but b
it will be enlarged by a green or bluish circum

OXIGENATED MURIATIC ACID GAS.

PART XXX.

SECT. I.

WHEN the muriatic acid gas before-mentioned, becomes combined with a certain quantity of oxigen, the result is an expansible gazeous fluid to which chemists have given the name of oxigenated muriatic acid gas.

PROPERTIES OF OXIGENATED MURIATIC ACID GAS.

Oxigenated muriatic acid gas possesses an uncommonly pungent and suffocating odour. It is absolutely and in every respect non-respirable; animals immersed in it die instantly. It is absorbable by water, and forms with it what is called liquid oxigenated muriatic acid. When water is saturated with it, the compound crystallizes at low temperatures. Oxigenated muriatic acid gas is not *invisible*, but has a *yellow-greenish colour*. It is capable of maintaining and exciting combustion in many cases.

Phosphorus, charcoal, red sulphuret of mercury, sulphuret of antimony, bismuth, iron, zinc, copper, gold, arsenic, cobalt, tin, lead, and several other combustible bodies take fire spontaneously when introduced into it. It is heavier than atmospheric air. It weakens and reddens the flame of a taper, but does not extinguish it. It decomposes ammonia. It thickens fat oils. It detonates with hidrogen gas. Nitrous gas immediately produces a cloud of reddish vapour with it. It is likewise decomposed by sulphurated, phosphorated and carbonated hidrogen gases. It is not altered by exposure to light, and passes unaltered through an ignited porcelain tube. It discolours stuffs and totally destroys most of the vegetable colours, rendering them white. It also bleaches yellow wax, &c.

METHODS OF OBTAINING OXIGENATED MURIATIC ACID GAS.

1. Put into a retort one part of powdered black oxid of manganese and three or four of concentrated muriatic acid, connect the retort with the pneumatic trough and receive the gas over *water** in the usual manner. When no more gas is liberated apply the heat of a lamp, and gas will be produced abundantly, which may be kept in bottles with ground glass stoppers.

RATIONALE...The oxid of manganese yields up part of its oxigen to part of the muriatic acid, which becomes converted into oxigenated muriatic acid gas; the oxid of manganese being thus partly de-oxidated is dissolved in the remaining quantity of the muriatic acid, which remains behind in the retort as muriate of manganese.

REMARK...The retort containing the mixture should not be filled above one-third, for the mixture on the application of heat, swells and is otherwise very apt to be forced over into the neck of the retort.

* Though mercury is generally made use of in this process, water answers the purpose very well.

2. Oxigenated muriatic acid gas may likewise be obtained in an indirect manner by decomposing muriate of soda in contact with black oxid of manganese. For that purpose mix eight parts by weight, of muriate of soda with three of powdered oxid of manganese, put the mixture into a tubulated retort, and pour upon it gradually four parts of sulphuric acid, diluted previously with three of water, and which has been suffered to cool after dilution. On applying a gentle heat, gas will be produced as before.

Rationale...In this operation the sulphuric acid acts on the muriate of soda, to the base of which it unites; the muriatic acid formed by this union, attacks the oxid of manganese; one part of it combines with the oxigen and another with the oxid brought nearer to the metallic state, and the result is sulphate of soda and muriate of manganese, which remain in the distilling vessel; and oxigenated muriatic acid, which passes in the state of gas at common temperatures.

Remarks...In preparing this gas great care should be taken that it does not escape into the apartment in any considerable quantity; as it acts violently on the pituitous membrane, occasions a defluxion of the brain, blunts the senses of smell and taste, produces head-ache and proves extremely injurious to health.

Pelletier fell a sacrifice in attempting to breathe it; a consumption was the consequence which proved fatal.

Liquid ammonia is the remedy best calculated to check its effects when accidentally set at liberty in places where it is prepared.

The water which adheres to the inner side of the vessel filled with oxigenated muriatic acid gas, crystallizes in the form of yellow spangles, if the temperature is near the freezing point. If a considerable quantity of gas be thus condensed, care must be taken to keep it at a low temperature, for as soon as the temperature is raised, it expands, and endangers the bursting of the vessel.

ONALE...This effect can be ascribed only to the absorp-
oxigen. This gas which contains it in excess, gives up a
it, which vegetable substances absorb with avidity; and
absorption lose their colour: the oxigenated muriatic acid
n becomes converted into common muriatic acid gas.

ARK...It is this property which induced a new method of
ng which has proved completely successful. The ad-
es which result from this application of the oxigenated
ic acid, either in the gazeous or the liquid state have ac-
ed the process of whitening thread, cotton, linen, wax,
a really surprising degree, in every season of the year,
an be justly appreciated by commercial people only, who
ience its beneficial effects from the quick circulation of
capitals.

Experiment III.

ching of linen, calico, &c. by oxigenated muriatic acid gas.

pend some unbleached calico or linen moistened with wa-
a jar filled with oxigenated muriatic acid gas. The natural
r of the stuff will soon begin to fade, and at last totally
pear.

different coloured patterns of calico or printed cotton be im-
d for a few minutes into the gas, their colours will soon be
yed, except those which are yellow.

Experiment IV.

Oxigenated muriatic acid gas supports flame.

ough oxigenated muriatic acid gas is exceedingly noxious to
it does not extinguish combustion.
a burning taper affixed to a wire be immersed in it, the
burns of a red colour and more vividly than in atmospheric
a great quantity of smoke is emitted at the same time.

Experiment XI.

Accension of expressed oils at the surface of water, by oxigenated muriatic acid gas.

Put into a glass cylinder one part of oxigenated muriate of potash; add to it three or four of water, and half a part of oil of olives, or of linseed. On adding to it four or five parts of concentrated sulphuric acid, a violent action takes place, much charcoal becomes deposited, and a multitude of ignited sparks pass through the black fluid, exhibiting a beautiful phenomenon. On adding an additional quantity of oxigenated muriate of potash and sulphuric acid, the whole mass takes fire and burns with a dense yellow flame.

Experiment XII.

Accension of phosphorus in oxigenated muriatic acid gas, under the surface of water.

Let fall into a wine-glass, or rather into a long cylinder, two-thirds filled with water, one part of phosphorus, and two of oxigenated muriate of potash. On adding to this mixture three or four parts of sulphuric or nitric acid, the phosphorus takes fire, and burns vividly *under the surface* of the fluid: on agitating the mixture, streams of ignited sparks pass through the water rapidly.

Remark...This and the two preceding experiments require caution. The operator ought to be distant during the affusion of the acids, or the addition of the combustible body, which are sometimes thrown out of the vessel to a considerable distance.

Experiment XIII.

Nitrous gas and oxigenated muriatic acid gas, readily unite and produce nitro-muriatic acid.

This may be shown by sending up into a receiver filled with oxigenated muriatic acid gas, bubbles of nitrous gas; the mixture

FLUORIC ACID GAS.

PART XXXI.

SECT. I.

composition, or the radical of fluoric acid gas is equally wn; for no experiments have yet been made by which be exhibited. It is merely from general inference, that ly conjecture it to consist of a simple acidifiable basis to oxigen.

PROPERTIES OF FLUORIC ACID GAS.

most remarkable property of this gas, is its power of dis- silex, and keeping it suspended in the gazeous state; it re dissolves glass, crystals and various precious stones. It ier than atmospheric air. It does not maintain combustion, animals breathe it. It is absorbed by water and forms liquid fluoric acid. It has a penetrating odour, approach- arly to that of muriatic acid gas. It corrodes animal and ble matters. Light has no effect upon it. It emits white in contact with moist atmospheric air. It is very sour and re reddens blue vegetable colours. It precipitates lime

water. With ammonia it unites and forms a concrete body. It has no action upon platina, gold, silver, mercury, tin, lead, antimony, cobalt, nickel, or bismuth; but it attacks iron, arsenic, and manganese.

METHODS OF OBTAINING FLUORIC ACID GAS.

1. Fluoric acid gas may be obtained by decomposing fluate of lime (Derbyshire spar) by means of sulphuric acid.

For that purpose, put one part of powdered fluate of lime into a leaden or tin retort, and pour over it two or three parts of concentrated sulphuric acid. A violent action takes place instantly and fluoric acid gas is extricated which must be collected over mercury, either in a leaden or tin vessel, or in a glass receiver covered within with a thick coat of varnish or wax. When no more gas is produced spontaneously, the action of the acid must be assisted by a gentle heat.

RATIONALE...Fluate of lime consits of fluoric acid united to lime; on adding sulphuric acid a decomposition takes place. The sulphuric acid having a greater attraction for the lime than the fluoric acid, unites to it and forms sulphate of lime, disengaging at the same time the fluoric acid, which takes the gazeous state at the instant of its extrication and appears under the form of fluoric acid gas.

2. Fluoric acid gas may likewise be obtained from liquid fluoric acid, (water impregnated with fluoric acid gas) by heat.

SECT. II.

EXPERIMENTAL PROOFS

OF

THE PROPERTIES OF FLUORIC ACID GAS.

Experiment I.

Fluoric acid gas is absorbable by water.

INTRODUCE into a receiver coated within with wax, and filled with fluoric acid gas, a little water, and agitate it; heat will be produced, the gas will vanish, and the mercury rise into the receiver.

If the water be examined, it will be found to possess all the properties of fluoric acid, it will corrode glass, quartz, and other siliceous substances. If it be exposed to heat, part of the absorbed gas becomes extricated again, but the last portion adheres to it so strongly that the water and the rest of the acid are volatilized if the heat be increased.

Experiment II.

Fluoric acid gas extinguishes light and kills animals.

If a lighted taper be plunged into a vessel filled with this gas it will instantly be extinguished. An animal thrown into it soon dies.

REMARK...The art of etching on glass, which is generally considered as of modern date, does not entirely belong to our cotemporaries; even to assert that the ancients were altogether unacquainted with it, would be unjust. It seems rather that this art belongs to the discoveries which were made in those times, in which men were little inclined to transmit an account of their inventions to posterity, and thus may have been forgotten or lost. Scheele discovered the fluoric acid and re-invented the art of etching on glass, in 1771. But that it was practised a century before, by a German, whose name was *Swanhard*, we have endeavoured to prove in *Nicholson's Journal for April*, 1800.

Had this person been able to pursue properly the discovery which either accident or ingenuity presented to him, he might have enriched us with an art which acquired great reputation to Scheele a hundred years after.

EXPERIMENT V.

Fluoric acid gas not only dissolves, but also volatilizes siliceous earth.

This may be shown by decomposing fluate of lime in a glass retort, and receiving the gas in a vessel filled with water, and resting upon mercury. Each bubble of the gas which passes through the mercury into the water becomes immediately enveloped in silex, and leaves, as it ascends to the surface of the water, traces in the form of tubes, which frequently decrease to a point upwards, because the bubble diminishes in proportion as the water dissolves it, and the silex is carried off.

RATIONALE...The gas when disengaged in the glass retort dissolves part of the silex of that vessel, which it keeps in an aeriform state. On coming into contact with the water it abandons its caloric and becomes converted into liquid fluoric acid, depositing at the same time the siliceous earth.

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... more fully into the
... is promised to investigate

THEORIES

OF

COMBUSTION.

PART XXXII.

MONG the various operations of chemistry none acts a more
›icuous part than combustion; and in proportion to its uti-
n the science, the necessity of thoroughly investigating its
e and mode of action becomes more obvious to the philoso-
l chemist. It was a conviction of the importance of this
ry which induced Lavoisier to examine with accuracy the
rs of his predecessors, and by this pursuit he was enabled
rm a theory of this process, which though not absolutely
rom error, was such as well entitled its author to the dis-
ished rank he holds among philosophers. And as this
y, though capable of improvement, will probably serve for
ndation to every discovery which may be made in this
h of the science, we shall state it here with a view that our
rs may be enabled to appreciate its value.

SECT. I.

LAVOISIER's THEORY OF COMBUSTION.

LAVOISIER's theory of combustion is founded upon the absorption of oxigen by a combustible body.

We have seen that bodies cannot burn in a limited quantity of air beyond a certain period; (page 222) that a real analysis of this fluid is effected; and that combustion is not confined to the decomposition of the atmosphere only, by absorbing one of its principles; but that it also decomposes oxigen gas, by absorbing, fixing, and rendering more or less solid, in the combustible body, the oxigen or basis of the oxigen gas, and disengaging its solvent, the caloric, under the appearance of heat and flame. *See page* 188.

Taking this for granted, it follows that combustion is only the play of affinity between oxigen, the matter of heat, and a combustible body.

When an *incombustible* body, a brick for instance, is heated, it undergoes no change except an augmentation of bulk and temperature, and when left to itself it soon regains its former state. But when a *combustible* body is heated to a certain degree in the open air it begins to become on a sudden intensely hot, and at last emits a copious stream of caloric and light to the surrounding bodies. During this emission the burning body gradually wastes away. It either disappears entirely, or its physical pro-

perties become totally altered. The principal change it suffers is that of being no longer capable of combustion.

If either of these phenomena, namely, the emission of heat and light, and the waste of substance, be wanting, we do not say that a body is undergoing combustion, or that it is burning.

It follows therefore that every theory of combustion ought to explain the following facts:

1. Why a burning body is consumed, and its individuality destroyed.

2. Why, during the progress of this alteration, heat and light are emitted.

For the elucidation of these objects Lavoisier's theory has laid down the following laws:

1. Combustion cannot take place without the presence of oxigen, and is more rapid in proportion to the quantity of this agent in contact with the inflamed body.

2. In every act of combustion the oxigen present is consumed.

3. The weight of the products of every body after combustion corresponds with the weight of the body before combustion *plus* that of the oxigen consumed.

4. The oxigen absorbed by the combustible body may be recovered from the compound formed, and the weight regained will be equal to the weight which disappeared during the combustion.

5. In every instance of combustion light and heat or fire, are liberated.

6. In a limited quantity of air, only a certain quantity of the combustible body can be burnt.

7. The air, wherein a body has been burnt, is rendered unfit for maintaining combustion, or supporting animal life.

Though every case of combustion requires that light and heat should be evolved, yet this process proceeds very differently in different circumstances, hence the terms *ignition*, or glowing heat; *inflammation* or accension; and *detonation* or explosion.



maintained. The tallow is liquefied as it comes into the vicinity of the flame, and is by the capillary attraction of the wick drawn up to supply the place of what is decomposed; the unmelted tallow by this means forms a kind of cup.

The congeries of capillary tubes which form the wick is black, because the charcoal of the cotton becomes predominant, the circum-ambient air is defended by the flame from oxidating it, it therefore remains for a considerable time in its natural state; but when the wick by the continual consumption of tallow becomes too long to support itself in a perpendicular position, its upper extremity projects nearly out of the cone of the flame, and there forms a support for an accumulation of soot, which is produced by the imperfect combustion. A candle in this situation affords scarcely one-tenth of the light it can give, and tallow candles on this account require continual snuffing.

But if the candle be made of wax, the wick does not long occupy its place in the middle of the flame; its thinness makes it bend on one side when its length is too great for its vertical position; its extremity comes then into contact with the air, and is completely burnt or decomposed, except so much of it as is defended by the continual afflux of the melted wax. This small wick therefore performs the office of snuffing itself. The difficult fusibility of wax enables us to use a thinner wick for it, than can be used for tallow which is more fusible. But wax being a substance which contains much more oxigen than tallow or oil, the light it affords is not so luminous.

DETONATION

is an instantaneous combustion accompanied with a loud report; it takes place in general when the compound resulting from the union of two or more bodies occupies less space than the substances did before their union, a vacuum is therefore formed, and the surrounding air rushing in from all sides to fill it up is the cause of the report.

Though *approaching* to the truth, this explanation is not strictly true. It is not merely from the oxigen gas being *condensed* that the caloric is evolved, because in many cases of combustion, the product still exists in the gazeous state, (see p. 190) and in others the quantity of caloric evolved bears no proportion to the degree of condensation. Philosophers ascribed this to a change of capacity, for in different bodies the difference in the proportion of the capacities before and after combustion is by no means uniform, and hence the difference in the quantities of caloric extricated in various cases of combustion.

This being premised it remains to explain the origin of the light emitted during combustion; for although we take it for granted that the caloric is evolved from the oxigen gas, we cannot infer that the light has the same origin.

It is very probable that light is a constituent part of inflammable bodies; for it is frequently evolved in combinations when the oxigen is merely *transferred* from one inflammable substance to another. In those cases it must proceed from the inflammable body. The accension of oils by the affusion of acids (page 19) the combustion of metals with sulphur (page 149) furnish intances of the kind.

It seems therefore probable that the light is derived from the inflammable substance; and that the oxigen combining with the bases of these substances disengages the light. It is *possible* that part of it may also be derived from the oxigen gas, but it is evidently unnecessary to *suppose so*.

It may be concluded then that light enters into the composition of all combustible bodies, but as we are unable to separate the light so as to obtain these bodies pure we treat of them as simple bodies.

According to this theory the combustion of phosphorus in oxigen gas (page 188) is therefore the effect of a double affinity. The basis of the oxigen gas unites with the phosphorus to form phosphoric acid; and the light disengaged from the phosphorus

together with part of that of the oxigen gas, produces the vivid flame.

The quantity of light emitted by different bodies is supposed to depend on the quantity contained in them, and on the proportion in which it is united to caloric.

Such is the theory of combustion of Lavoisier modified by Gren, Leonhardi, Richter, and publicly taught in this capital by Dr. Crichton.

Other teachers consider this theory as a modification of the old doctrine of Stahl, saying that light is substituted for phlogiston, but this is a mere verbal conceit which probably only originates from the prejudice which the partizans harbour in favour of the original theory of Lavoisier.

SECT. II.

THOMSON's

THEORY OF COMBUSTION.

THOUGH the preceding theory of combustion is simple and beautiful, it appears from what we are now going to state, to be by no means satisfactory.

It has misled chemists by confining the term combustion to the act of oxigenation, and considering that all bodies, during their combustion, combine with oxigen, without at the same time recollecting, that this latter effect may take place without any of the phenomena usually attendant on combustion; and that, though certainly all combustion pre-supposes the combination of oxigen with a base, yet this combination may be, and repeatedly is effected where no combustion can possibly take place. Nothing can be more evident than the difference which in numberless instances prevails between the act of oxigenation in bodies, and that of combustion, in as much as neither the phenomena attending on, nor the results arising from them are the same. That a distinction therefore should be made between these processes is obvious; and it is on this account that Dr. Thomson has offered a theory which considers this subject in a new point of view, and which bids fair to enable us to estimate the phenomena of combustion much better than has hitherto been done.

According to Dr. Thomson's* theory, all the bodies concerned in combustion are either, 1. *Combustibles*...2. *Supporters of combustion*...3. *Incombustibles*.

1. COMBUSTIBLE BODIES are those substances which are said in common language to *burn*. During the combustion they appear to emit light and heat, and at the same time gradually waste away. When this change has reached its *maximum*, the process of combustion is at an end.

The class of combustibles is very numerous; but all the bodies belonging to it may be sub-divided into three sets, namely;

1. Simple combustibles,
2. Compound combustibles,
3. Combustible oxids.

Simple Combustibles.

1. SULPHUR,
2. PHOSPHORUS,
3. DIAMOND,
4. HIDROGEN GAS,
5. ALL THE METALS.

Compound Combustibles.

The *compound combustibles* consist of compounds, formed by the simple combustibles uniting together two and two, and are of course much more numerous than the simple combustibles. They may be arranged under the five following heads:

1. SULPHURETS,
2. PHOSPHURETS,
3. CARBURETS,
4. ALLOYS,
5. SULPHURATED, PHOSPHORATED, AND CARBONATED HIDROGEN.

The *combustible oxids* are either simple, having a single base, or compound, having more than one base. All the simple combustible oxids, are by combustion converted into acids.

* Nicholson's Journal, 1802, No. V. p. 10.

The compound combustible oxids are by far the most numerous.

II. The SUPPORTERS of COMBUSTION are bodies which are not of themselves, strictly speaking, capable of undergoing combustion, but which are absolutely necessary for the process; for no combustible body can burn unless some one or other of them be present. Whenever they are excluded, combustion ceases. All the supporters of combustion known at present are the following six:

1. OXIGEN GAS, 2. AIR,
3. GAZEOUS OXID OF NITROGEN,
4. NITROUS GAS, 5. NITRIC ACID,
6. OXIGENATED MURIATIC ACID.

There are indeed certain substances besides these, which possess nearly the same properties; these shall be afterwards enumerated under the title of *partial supporters*.

They all contain one common principle, namely *oxigen*.

III. The INCOMBUSTIBLE BODIES are neither capable of undergoing combustion themselves, nor of supporting the combustion of those bodies that are; they are therefore not immediately connected with combustion. At present we are acquainted with about 13 incombustible bodies, not reckoning the compounds which they are capable of forming with each other. These are,

1. NITROGEN GAS, 2 THE ALCALIES,
3 THE EARTHS.

Some of the alcalies and earths possess certain properties in common with combustibles, and are capable of exhibiting phenomena somewhat analagous to combustion; which will be described afterwards under the title of *semi-combustion*.

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Thus one of the two characteristic m
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combustible body, has been fully explaine
of it we are indebted to Lavoisier, as sta

But though the combination of the ca
be a constant part of combustion, yet t
combustibles burn is not proportional to
for oxigen.

Phosphorus, for instance, burns more
yet charcoal is capable of abstracting ox
and of course has a greater affinity for it.
combustible oxids take fire more readily t
combustibles: thus charcoal burns more
(page 173); alcohol, ether, and oils, are
ble, whereas all the metals require very h
ths supporter is air.

This greater combustibility of combus
owing to the weaker affinity by which th

It is owing to the same inferiority in the cohesion of heterogeneous particles, that some of the compound supporters occasion combustion in circumstances when the combustibles would not be acted on by simple supporters.

Thus phosphorus burns in air at the common temperature; (p. 158) but it does not burn in oxigen gas, unless its temperature be raised* (p. 188). In oxigenated muriatic acid gas, phosphorus burns rapidly at the common temperature of the air, and so do several of the metals; though they cannot be made to burn in air except at a very high temperature. Thus also oils burn rapidly when mixed with nitrous acid (page 19). Nitrous gas and the gazeous oxid of nitrogen constitute exceptions to this rule.

4. None of the *products* of combustion are combustible according to the definition of combustion here given. This want of combustibility is not owing to their being saturated with oxigen; for several of them are capable of combining with an *additional dose* of it. But during this combination no caloric or light is ever emitted; and the compound formed differs essentially from *a product* of combustion; for by this additional dose of oxigen the *product* is converted into a *supporter*. *Hence we see that combustion ought not to be confounded with the combination of a body with oxigen*, as was done formerly.

Combustion indeed cannot take place without the combination of oxigen; but oxigen may combine with bodies in different proportions without the phenomena of combustion; and the *product obtained* is capable of becoming converted into a *supporter of combustion*, for instance: If lead be melted, and kept so for some time, it becomes covered with a white pellicle, or white *oxid of lead*, a product consisting of oxigen and lead; but if this white oxid is suffered to be heated longer, it absorbs an additional quantity of oxigen, and becomes converted into a yellow

* In the gazeous oxid of nitrogen it requires a still higher temperature.

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les. The process therefore differs essentially from combustion. us sulphuric acid, a *product* of combustion, by combining th an additional dose of sulphur or its oxid, is converted into *lphureous acid*, a substance which, from several of its proper- s, the doctor concludes to be combustible. Thus also phos- oric acid, a product of combustion, is capable of combining th phosphorated hidrogen, and of forming *phosphorous* acid a mbustible body. When this last acid is heated in contact with supporter, it undergoes combustion; but it is only the addi- nal dose of the combustible which burns, and the whole is verted into phosphoric acid. Hence we see that it is not the ole basis of these compounds which is combustible, but mere- he additional dose. The compounds, therefore, formed by union of a product and combustible, may be termed *partial Combustibles*; indicating by the name, that a part only of the e is capable of undergoing combustion. Since the products of mbustion are capable of combining with oxigen, but never ex- it the phenomena of combustion except when they are in the e of partial combustibles, combustible bodies must contain a stance which they lose in burning, and to which they owe ir combustibility; for after they have lost it, they unite to ox- n *without* exhibiting the phenomena of combustion.

Though the products of combustion are not capable of support- combustion, they not unfrequently part with their oxigen just s upporters do, give it out to combustibles, and convert them o products; but during this process no heat nor light is ever olved. Water, for instance, gives out its oxigen to iron, and verts it into *black oxid*, a product; and sulphuric acid gives its oxigen to phosphorus, and converts it into phosphoric d. Thus we see that the oxigen of products is capable of con- ting combustibles into products, just as the oxigen of sup- ters; but during the combination of the last only, are heat d light emitted. The oxigen of supporters then contains some- ng which the oxigen of products wants.

we have only to mix water with iron or zinc filing
the metal is oxidated, and the hidrogen gas is ev
bustible as ever. But no substance, except a com
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From these facts it is obvious, that the produc
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that base then is restored by the loss of its oxig
restoration of something which it receives from
bustible thus converted into a product.

There is indeed another method of forming t

namely, nitrous gas; ammonia, a new combustible, is also usually formed; and not unfrequently the *product* is converted into a *partial supporter*.

7. No *supporter* can be produced by combustion, or by any equivalent process. As all the supporters, except oxigen gas, consist of oxigen combined with a base, it follows as a consequence, that oxigen may combine with a base without losing that ingredient, which occasions combustion. The act of combination of oxigen with a base, therefore, is by no means the same with combustion. If we take a view of the different supporters, we shall find that all of them which can be obtained artificially, are procured either from other supporters, or by the agency of electricity.

I. OXIGEN GAS may be procured from nitric acid and oxigenated muriatic acid, (p. 185...6) two supporters; and from several of the partial supporters, as the black oxid of manganese the red oxids of lead and of mercury (page 187). The action of heat is always necessary; but the process is very different from combustion.

II. AIR, as far as is known at present, cannot be formed artificially. The gas indeed which comes over during part of the usual distillation of nitrate of potash and sulphuric acid to obtain nitrous acid, resembles air very closely. But it is obtained from a supporter.

III. The GAZEOUS OXID OF NITROGEN has hitherto been only procured from nitrous gas and nitric acid (nitrate of ammonia), both of which are supporters.

IV. NITROUS GAS can only be procured by the decomposition of nitric acid, a supporter.

V. OXIGENATED MURIATIC ACID can be formed by combining muriatic acid with the oxigen of the black oxid of manganese, the red oxids of lead, iron, mercury, (page 335) &c. all of which are partial supporters.

VI. NITRIC ACID is formed spontaneously upon the surface of the earth by processes with which we are but imperfectly ac-

quainted; but which certainly have no resemblance to combustion. Its oxigen is probably furnished by the *air*, which is a supporter: at least, it has been observed, that nitrogen and oxigen at high temperatures are capable of forming nitric acid, (page 211).

This formation of nitric acid by means of electricity, has been considered as a combustion, but for what reason it is not easy to say: the substance acted upon is not a combustible with a supporter, but a supporter alone. Electricity is so far from being equivalent to combustion, that it sometimes acts in a manner diametrically opposite; *unburning*, if we may use the expression, a substance which has already undergone combustion, and converting a *product* into a *combustible* and a *supporter*. Thus it decomposes water, and converts it into oxigen and hidrogen gas; therefore it must be capable of supplying the substances which the oxigen and combustible lose when they combine by combustion, and form a product.*

8. Several of the supporters and partial supporters are capable of combining with combustibles, without undergoing decomposition, or exhibiting the phenomena of combustion. In this manner the yellow oxid of gold and the white oxid of silver combine with ammonia; the red oxid of mercury with oxalic acid; and oxigenated muriatic acid with ammonia. Thus also nitrate of potash and oxigenated muriate of potash may be combined, or at least intimately mixed with several combustible bodies, as in gunpowder, fulminating powder, &c. In all these compounds the oxigen of the supporter and the combustible retain the ingredients which render them susceptible of combustion; hence the compound is still combustible: And in consequence of the intimate combination of the component parts, the least alteration is apt to destroy the equilibrium which subsists between them; the consequence is, combustion and the formation of a new com-

* The doctor does not mean to affirm that electricity never occasions combustion, the contrary of which is well known, but that a combination produced by it is not always the same with combustion.

pound. Hence these compounds burn with amazing facility, not only when heated, but when triturated or struck smartly with a hammer. They have therefore received the name of *detonating* or *fulminating* bodies. Thus we have fulminating gold, fulminating silver, fulminating mercury, fulminating powder, &c.

9. Such are the properties of the combustibles, the supporters, and the products; and such the phenomena which they exhibit when made to act upon each other.

If we compare together the *supporters* and the *products*, we shall find that they resemble each other in many respects. Both of them contain oxigen as an essential constituent part; both are capable of converting combustibles into products; and several of both combine with combustibles and with additional doses of oxigen. But they differ from each other in their effects on combustibles. The former only produce combustion; whereas the products convert combustibles into products without combustion. Now, as the ultimate change produced upon combustibles by both these sets of bodies is the same, and as the substance which combines with the combustibles is in both cases the same, namely oxigen, we must conclude that this oxigen in the supporters contains something which the oxigen of the products wants, something which separates during the passage of the oxigen from the product to the combustible, and occasions the combustion, or emission of fire, which accompanies this passage. The oxigen of supporters then contains some ingredient which the oxigen of products wants. Many circumstances concur to render it probable that this ingredient is *caloric*.

The *combustibles* and the *products* also resemble each other. Both of them contain the same or a similar base; both frequently combine with combustibles, and likewise with oxigen; but they differ essentially in the phenomena which accompany their combination with oxigen. In the one case *fire is emitted*, in the other not. If we recollect that no substance but a combustible is capable of restoring combustibility to the base of a product, and that at its doing so it always loses its own combustibility;

... takes place. The oxigen of the product combines with ... of the combustible, while the light of the combustible ... with the base of the product.

The application of this theory to all the different phenomena ... above, is so obvious, that it is needless to give any ... examples. Let us rather inquire, with the author, into the ... which can be brought forward in its support.

... caloric and light are always emitted during combustion, ... that they must have previously existed in the combustible, the supporter, or in both.

... the oxigen of the supporters contains either one or both ... substances, follows inconvertibly from a fact already ... namely, that the oxigen of products will not support ..., while that of supporters will. Hence the oxigen of ... must contain something which the oxigen of the products ..., and this something must be caloric, or light, or

... the oxigen of some of the supporters at least contains ... an ingredient, has been proved, in a satisfactory manner, ... experiments of Crawford, Lavoisier, and La Place. Thus ... perature of hot blooded animals is maintained by the de... tion of *air*. Now if the oxigen of one supporter contains ... the same ingredient must exist in the oxigen of every ..., because all of them are obviously in the same state. ... we conclude that the oxigen of every supporter contains ... an essential ingredient.

... light emitted during combustion must either proceed from ...bustible or the supporter. That it proceeds from the ...tible must appear pretty obvious, if we recollect that the ... of the light emitted during combustion varies, and that ...iation usually depends, not upon the supporter, but upon ...bustible. Thus charcoal burns with a red flame, sulphur ...blue or violet, zinc with a greenish white, &c.

combine with potash, or with lime, in a crucible or glass tube, and likewise when melted phosphorus is made to combine with lime heated to redness, (page 165). He supposes that in all probability barytes and strontia exhibit the same phenomenon when combined with melted sulphur or phosphorus; and perhaps some of the metals when combined with phosphorus.

The phenomena Dr. Thomson explains thus: The sulphur and phosphorus are in the melted state, and therefore contain caloric as an ingredient; the alcalies, earths and metals which produce the phenomenon in question, contain light as an essential ingredient. The sulphur or phosphorus combines with the base of the metal, earth or alcali; while at the same time the *caloric* to which the sulphur or phosphorus owed its fluidity, combines with the *light* of the metal, earth or alcali; and the compound flies off under the form of *fire*.

Thus the process is exactly the same with combustion, excepting as far as regards the product. The melted sulphur or phosphorus acts the part of the *supporter*, while the metal, earth or alcali occupies the place of the *combustible*. The first furnishes caloric, the second light, while the base of each combines together. Hence we see that the base of sulphurets and phosphurets resembles the base of products in being destitute of light, the formation of these bodies exhibiting the separation of fire like *combustion*, but the product differing from a product of combustion in being destitute of oxigen. Dr. Thomson distinguishes the process by the title of *semi-combustion*; indicating by the term, that it possesses one half of the characteristic marks of combustion, but is destitute of the other half.

The only part of this theory which requires proof is, that light is a component part of the earths and alcalies. But as potash and lime are the only bodies of that nature, which we are certain to be capable of exhibiting the phenomena of semi-combustion, the proofs must of necessity be confined to them. That *lime* contains light as a component part has been long known. Meyer

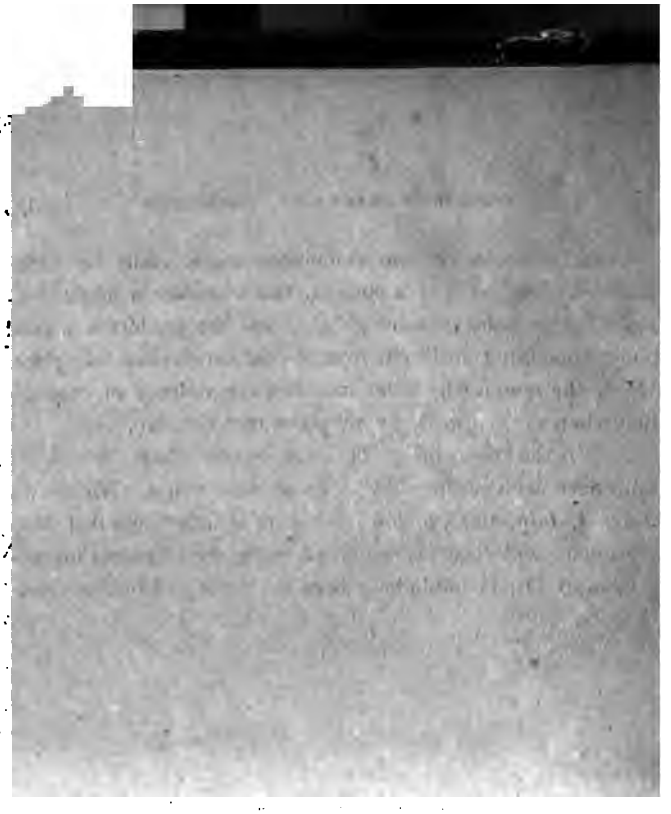




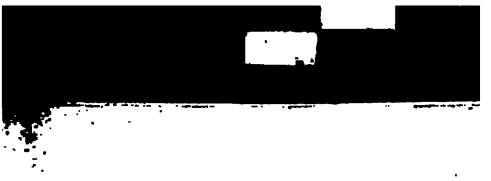
These remarks on semi-combustion might easily be much enlarged upon. For it is obvious, that whenever a liquid combines with a solid containing light, and the product is a solid body, something analogous to semi-combustion must take place. Hence the reason why water increases the violence of combustion when thrown sparingly into a common fire, &c.

Such is the theory of Dr. Thomson, against which a few objections have been advanced by an anonymous writer, *(Nicholson's Journal, July*, 1802, *p.* 206.) but there is little doubt that these objections will soon be reconciled, when the ingenious investigations of Dr. Thomson have been the subject of further consideration.

END OF VOL. I.



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